UNIVERSITI MALAYSIA PAHANG

BORANG PENGESAHAN STATUS TESIS ◆

JUDUL: <u>DESIGN AND DEVELOP AUTO CAR JACKER POWER BY INTERNAL CAR POWER</u>

SESI PENGAJIAN: 2007/2008

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DESIGN AND DEVELOP AUTO CAR JACKER POWER BY INTERNAL CAR POWER

AMIR ISKANDAR BIN ARIFFIN

A report submitted in partial fulfilment of the requirements
for the award of the degree of
Bachelor of Mechanical Engineering

FACULTY OF MECHANICAL ENGINEERING
UNIVERSITI MALAYSIA PAHANG

NOVEMBER 2008

SUPERVISOR'S 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

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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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ABSTRACT

The work in this study is in general described, an electrically operated car jack. A scissor type, automatically operated by switch buttons consists of a base, a load engaging head, gearing system and stabilizer base. The prototype includes motor powered from the cigarette lighter adapter. The motor with gearing system will be the lifting mechanism. When the car needed to be lifted, just press the button and release the button at a desired height level. The common problem faced by the current available car jacks in the market is it is manually operated and needed physical effort to lift the vehicle. All the analysis and results such as the torque needed and gearing ratio is important in this project before needed to be developed. The developed automatic car jacker is base on the result and analysis part to lift a kancil car (682kg). The stress and Von Mises stress are additional analysis on the gearing parts to know how much stress applied on the system to avoid failure. The developed automatic car jacker is a success which it able to lift a kancil's car according to the set scopes.

ABSTRAK

Projek ini adalah jek kereta yang dioperasi dengan menggunakan tenaga elektrik dari bateri kereta.Jek kereta jenis gunting dan dioperasi menggunakan system kawalan butang mengandungi tapak, kepala jek,sistem gear and tapak penstabil.Prototaip ini juga mengandungi motor yang dijanakan dari kuasa adapter dari kereta.Motor dengan sistem gear merupakan mekanisma pengangkat.Apabila kereta memerlukan untuk diangkat atau jek, cuma memerlukan menekan butang dan melepaskan butang pada ketinggian yang dikehendaki.Masalah utama yang terdapat pada jek kereta yang dijual pasaran adalah ia dioperasi secara manual dan memerlukan tenaga buruh yang tinggi.Semua analisis dan data seperti daya kilasan dan sistem gear ratio adalah penting dalam projek ini sebelum ia boleh dibina.Jek kereta automatik ini dibina daripada analysis dan data daripada kereta kancil (682 kg).Tekanan normal dan tekanan Von Mises adalah analisis tambahan pada system gear untuk mengetahui berapa nilai tekanan yang dikenakan pada gear.Ini adalah untuk mengelakkan kegagalan sistem.Prototaip jek kereta automatik yang dibina adalah satu kejayaan kerana berjaya jek kereta mengikut skop yang telah ditetapkan.

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ω	Natural frequency
σ	True stress, local stress
σ_{vm}	Stress Von Mises

LIST OF ABBREVIATIONS

List of Abbreviations

AISI	American Iron and Steel Institute
ALI	American Lift Instituition
ASTM	American Society for Testing and Materials
CAD	Computer-aided Drafting
ECM	Electronic Control Module
SAE	Society of Automotive Engineers
FEA	Finite Element Analysis
USMA	United States Marine Association

CHAPTER 1

INTRODUCTION

1.1 PROJECT MOTIVATION

An automotive jack is a device used to raise all or part of a vehicle into the air in order to facilitate repairs. Most people are familiar with the basic car jack (manually operated) that is still included as standard equipment with most new cars. These days, a car jack is an important tool to have in our vehicle due to unknown upcoming event such as flat tire in our journey. Even so, people who like to rotate their tires themselves or who may install snow tires before the winter and remove them in the spring need to use a jack to perform the job. Changing a flat tire is not a very pleasant experience.

Moreover, the 'USMA' report on the Integration and Performance of Women at West Point in Proceedings (July 1998) reveals sex-norming schemes whereby women. Navy studies show that only 12% of women can accomplish the two-person stretcher carry, a requirement critical to ship security. Women may be able to drive a five-ton truck, but need a man's help if they must change a tire. Women have a much lighter skeleton that means, among other things, she can't pull more forces as well as men and are at greater risk of skeletal injuries.

Usually the car purposely tries to get a flat tire at the least opportune moments. Like when you are rushing home from work, something emergency, business meeting or in the middle of the woods for instance. You are not going to be able to keep driving, so you are going to have to remove it and install your car's spare tire in its place. This is a waste of time and even will endanger you if you are jacking and changing the tire in hurry. Working near a vehicle that is supported by a car jack can be fatal. In Australia, over the last four years at least 19 people have been crushed and killed by a vehicle while they were working. All the deaths were men and involved the vehicle being lifted or supported in the wrong way. Home mechanics are most at risk of this type of death or injury. In some cases the worker was killed when the vehicle was not secured by chocks and the vehicle rolled on top of them, or the structures used to support the vehicle failed. On average, 160 injuries are associated with car jacks each year. Injuries have ranged from amputation to fractures and crush injuries. The correct use of jacks can prevent death or injury. With the spare installed, you should be able to reach your house or the nearest service station.

Furthermore, an organization called the American Lift Institute (ALI) was established to promote improvements in automotive lift technology, especially in the area of safety. As recently as the late 1990s, car lift or jack manufacturers were allowed to declare that their products were safe even though they did not meet any set standard. Thanks to ALI's cooperative venture with the American National Standards Institute, all jacks and lifts must meet a set number of performance standards in order to be ALI/ANSI certified. Improvement in automotive car jack is really needed to make the tool more efficient, user-friendly, practical to use, changes in industry direction and most importantly high safety features.

Further research on car jack is very important.

1.2 BACKGROUND

In the repair and maintenance of automobiles (car), it is often necessary to raise an automobile to change a tire or access the underside of the automobile. Accordingly, a variety of car jacks have been developed for lifting an automobile from a ground surface. Available car jacks, however, are typically manually operated and therefore require substantial laborious physical effort on the part of the user. Such jacks present difficulties for the elderly and handicapped and are especially disadvantageous under adverse weather conditions.

Furthermore, available jacks are typically large, heavy and also difficult to store, transport, carry or move into the proper position under an automobile. In addition, to the difficulties in assembling and setting up jacks, such jacks are generally not adapted to be readily disassembled and stored after automobile repairs have been completed. Suppose car jacks must be easy to use for pregnant women or whoever had problem with the tire in the middle of nowhere.

In light of such inherent disadvantages, commercial automobile repair and service stations are commonly equipped with large and hi-tech car lift, wherein such lifts are raised and lowered via electrically-powered systems. However, due to their shear size and high costs of purchasing and maintaining electrically-powered car lifts, such lifts are not available to the average car owner. Engineering is about making things simpler or improving and effective. Such electrical-powered portable jacks not only remove the arduous task of lifting an automobile via manually-operated jacks, but further decrease the time needed to repair the automobile. Such a feature can be especially advantageous when it is necessary to repair an automobile on the side of a roadway or under other hazardous conditions.

There also reports on car jacks which lead to a serious number of accidents. These are due of safety features that are on conventional car jacks are not enough. A specified jack purposed to hold up to 1000 kilograms, but tests undertaken by Consumer Affairs has revealed that is fails to work after lifting 250 kilograms and may physically break when it has a weight close to its 1000 kilograms capacity. Whilst no injuries have been reported to date, Ms Rankine has expressed concerned about the dangers associated with the use of a vehicle jack that does not carry the weight it is promoted to hold. Tests have proven that the jack has the propensity to buckle well under the weight it is promoted to withstand, and it doesn’t meet the labeling or performance requirements of the Australian Standard for vehicle jacks.

1.3 PROBLEM STATEMENT

Available jacks present difficulties for the elderly, women and are especially disadvantageous under adverse weather conditions. These presently available jacks further require the operator to remain in prolonged bent or squatting position to operate the jack.

Doing work in a bent or squatting position for a period of time is not ergonomic to human body. It will give back problem in due of time. Moreover, the safety features are also not enough for operator to operate the present jack. Present car jack do not have a lock or extra beam to withstand the massive load of the car. This is for the safety precaution in case if the screw break.

Furthermore, available jacks are typically large, heavy and also difficult to store, transport, carry or move into the proper position under an automobile. Suppose car jacks must be easy to use for pregnant women or whoever had problem with the tire in the middle of nowhere.

The purpose of this project is to encounter these problems. An electric car jack which has a frame type of design by using electric from the car lighter will be developed. Operator only needs to press the button from the controller without working in a bent or squatting position for a long period of time to change the tire.

1.4 OBJECTIVES

In order to fulfill the needs of present car jack, some improvement must be made base on the problems statement:

I. To design a car jack that is safe, reliable and able to raise and lower the height level.
II. To develop a car jack that is powered by internal car power and fully automated with a button system.

1.5 SCOPES

I. The developed automatic car jack can only withstand below 1000kg of load (Kancil 682kg)
II. The developed automatic car jack must be operated on a flat surface.
III. The developed automatic car jack is only a prototype and not readily functioning as commercial product.
IV. The design is based on current scissor jack in the market.
V. The developed automatic car jack is only for normal person.
VI. The developed automatic car jack can only work by using the internal car power (12V)

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

The main purpose of this literature review is to get information about the project from the reference books, magazines, journals, technical papers and web sites. In this chapter the discussion will be made base on all the sources.

2.2 TERMINOLOGY

In this section, all the terminology on this project is presented.

2.2.1 Jack

A mechanical jack is a device which lifts heavy equipment. The most common form is a car jack, floor jack or garage jack which lifts vehicles so that maintenance can be performed. Car jacks usually use mechanical advantage to allow a human to lift a vehicle. More powerful jacks use hydraulic power to provide more lift over greater distances. Mechanical jacks are usually rated for a maximum lifting capacity (for example, 1.5 tons or 3 tons).

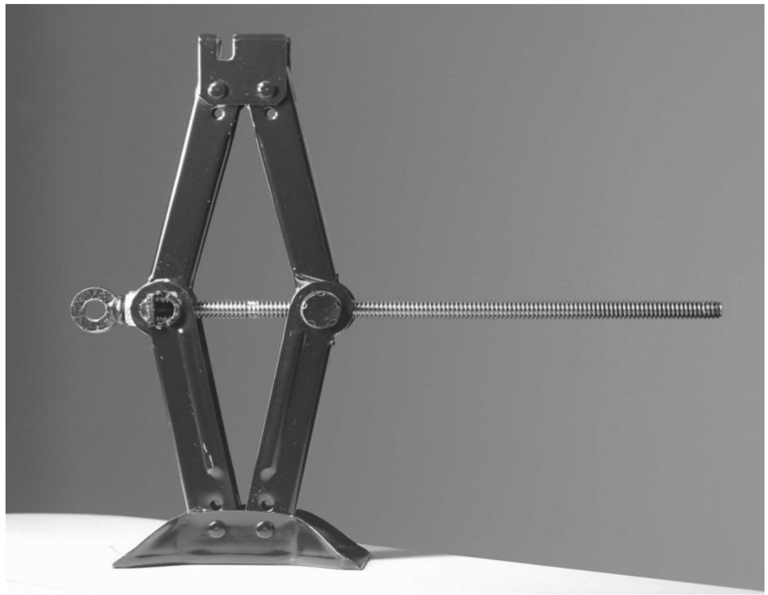


Figure 2.1: Typical scissors jack

2.2.2 Design

To design is either to formulate a plan for the satisfaction of a specified need or to solve a problem. If the plan results in the creation of something having a physical reality, then the product must be functional, safe, reliable, competitive, usable, manufacturable, and marketable.

These terms are defined as follows:

I. Functional: The product must perform to fill its intended need and customer expectation.
II. Safe: The product is not hazardous to the user, bystanders, or surrounding property. Hazards that cannot be ‘designed out’ are eliminated by guarding (a protective enclosure); if that is not possible, appropriate directions or warning are provided.
III. Reliable: Reliability is the conditional probability, at a given confidence level, that the product will perform its intended function satisfactorily or without failure at a given age.
IV. Competitive: The product is a contender in its market.

V. Usable: The product is ‘user friendly’ accommodating to human size, strength. Posture, reach, force, power and control.
VI. Manufacturable: The product has been reduced to a ‘minimum’ number of parts. Suited to mass production, with dimensions, distortion, and strength under control.
VII. Marketable: The product can be bought, and service (repair) is available.

It is important that the designer begin by identifying exactly how to recognize a satisfactory alternative, and how to distinguish between two satisfactory alternatives in order to identify the better. From this, optimization strategies can be formed or selected. Then the following tasks unfold:

- Invent alternative solution
- Establish key performance metrics
- Through analysis and test, simulate and predict the performance of each alternative, retain satisfactory alternatives, and discard unsatisfactory ones.
- Choose the best satisfactory alternatives discovered as an approximation to optimality.
- Implement the design

The characterization of a design task as a design problem can introduce the idea that, as a problem, it has solution.

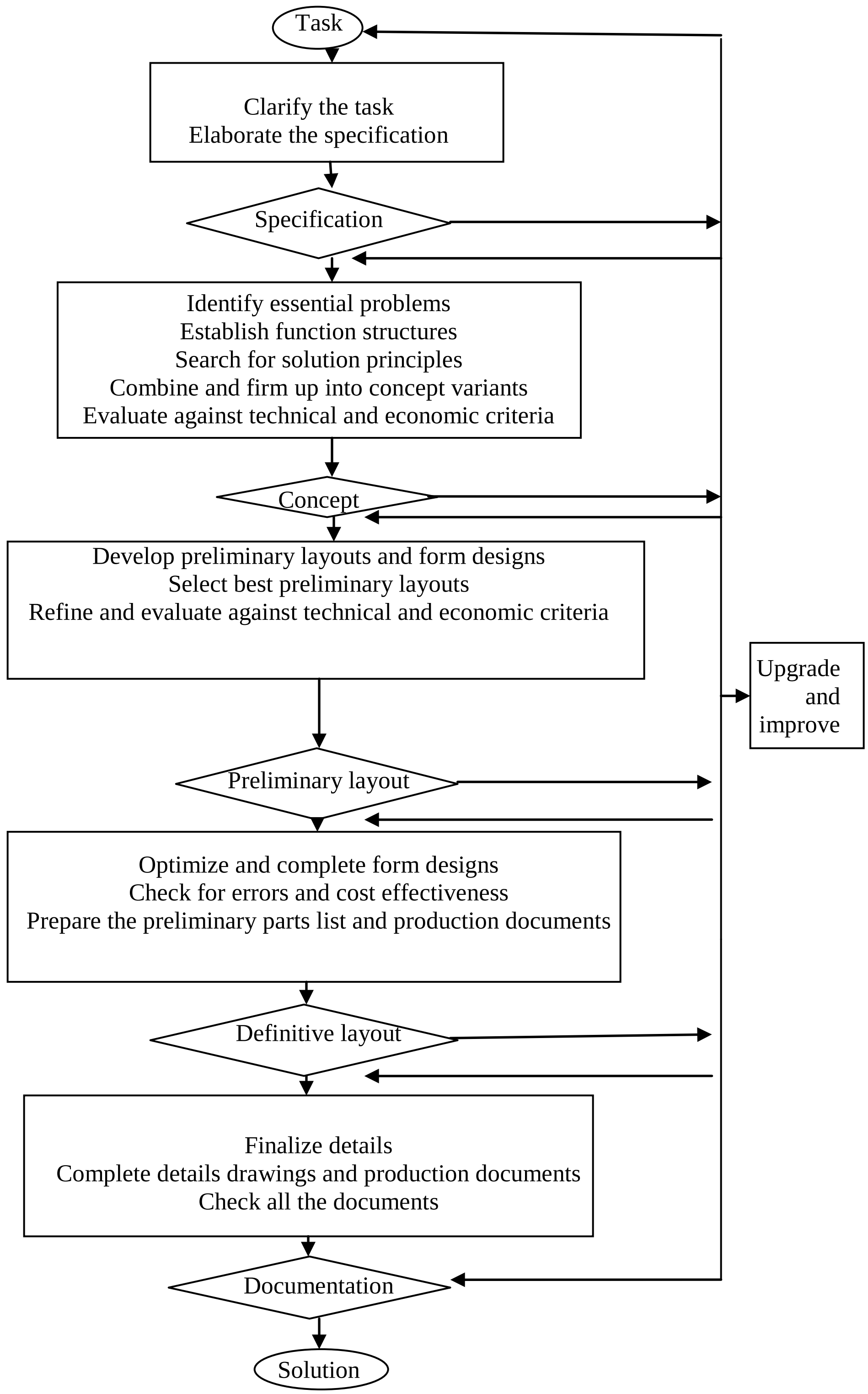


Figure 2.2: Pahl and Beitz Model of Design Process

2.2.3 Car (automobile)

The automobile is a self-propelled vehicle that travels on land. It usually has four wheels. An engine provides the power to move the vehicle. The automobile, or car, carries people primarily for their personal transportation. The first automobile was a gas buggy built by Karl Benz in Germany in 1885 and 1886.It had three wheels, one in the front and one in the rear.

There are many different styles of cars. Some people prefer a sports car like the Chevrolet Corvette. It seats only two, has limited luggage space, and is expensive. For most people, parts car is not the best family vehicle. Regardless the style, the automobile (car) is a type of motor vehicle. This is the name given to given to any self-propelled vehicle that does not run on rails. Two other types of motor vehicles are the truck and the bus. Motor vehicles are also called automotive vehicles.

In this project, the car that will be tested on the developed automatic car jack is kancil (660Ex) made by PERODUA.

Figure 2.3: Kancil 660EX

Table 2.1: Specification of Kancil cars

Model			660EX / Exb	850EX	850EXS	850EZi
Dimensions & Weight						
Overall Length		mm	3365		3385	3365
Overall Width / Height		mm	1405 / 1415			
Interior Length / Width / Height		mm	1710 / 1185 / 1170			
Wheelbase		mm	2280			
Track	Front	mm	1215			
	Rear	mm	1205			
Minimum Road Clearance		mm	175			
Kerb Weight		kg	681	702	720	717
Seating Capacity			5			
Minimum Turning Radius (Tyre)		m	4.4			

Source: PERODUA brochure (2000)

2.3 TYPE OF AUTOMOTIVE CAR JACKS

2.3.1 Scissors jack

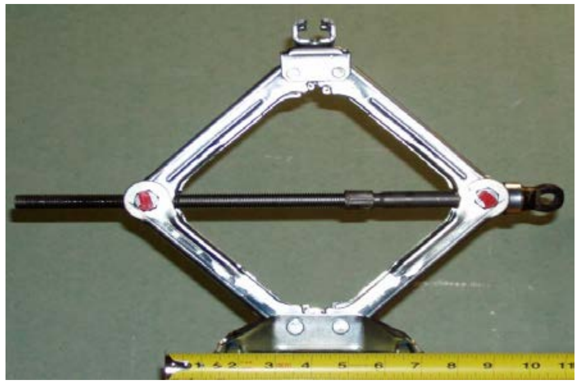


Figure 2.4: Scissor Jack

Use the basic concept of scissors to lift up vehicle**.**

2.3.2 Pneumatic jacks

There are many types of pneumatic jacks use air to raise one corner, end, or side of the car. Some lift under the front or rear bumper. Others lift under the axle housing or other lift points. Opening the air valve sends compressed air into the pneumatic cylinder. This causes the ram to extend and raise the vehicle. Reversing the lever exhausts the air. Then the vehicle settles back to the floor.

Figure 2.5: Pneumatic jacks

2.3.3 Hydraulic jacks

In automotive shop uses a variety of hydraulic jacks. One type is the portable floor jack. Pumping the handle increase the pressure in the hydraulic cylinder. This causes the ram to extend and raise the lifting saddle. Turning the top of the handle or moving a lever on the handle releases the pressure. Then the saddle and load settle back down.

Figure 2.6: Hydraulic jacks

2.3.4 A double post in ground lift.

Figure 2.7: A double post in ground lift

Lifts whose lifting assemblies are situated below the garage floor are known as in-ground lifts. These lifts employ one or more pistons, depending on the type of vehicle and how much weight is to be lifted. For example, many one or two-piston lifts are used to hoist compact, mid- and full-sized passenger vehicles. Three or more piston lifts are used mostly for larger vehicles, such as transit coaches and fire engines. In-ground lifts are manufactured to suit almost any type of vehicle and any type of under service; there is the basis single post model, the drive-through model, the drive over model, the pad type and the multi-post axle-engaging (fixed and movable piston) models to name a few. Moving the lift control causes an air or electric motor to operate a hydraulic pump. It sends liquid under pressure to the hydraulic cylinder. As the ram or post extends from the cylinder, the vehicle goes up.

2.4 PRODUCT QUALITY AND LIFE EXPECTANCY

Product quality and the techniques involved in quality assurance and control. The word quality is difficult to define precisely, partly because it includes not only well-defined technical considerations but also human (hence subjective) opinion. However, a high quality product generally is considered to have the following characteristics:

- It satisfies the needs and expectations of the customer, including cost.
- It is compatible with the customer’s working environment.
- It functions reliably and safely over its intended life.
- The aesthetics are pleasing.
- Installation, maintenance and future improvements are easy to perform and at low cost.

In view of the global economy and competition, a major priority on product quality is the concept of continuous improvement-as exemplified by the Japanese term Kaizen, meaning never-ending improvement. Low cost, low quality products have their own market niche, just as there is a market for high quality, expensive products such as a high-precision machine tool, a Rolls-Royce automobile, a private airplane or yatch, or sporting equipment.

2.5 MATERIALS

In this project material is an important factor to choose. We must consider a lot of thing before choose the right material.

Carbon steel, also called plain carbon steel, is a metal alloy, a combination of two elements, iron and carbon, where other elements are present in quantities too small to affect the properties. Steel with low carbon content has the same properties as iron, soft but easily formed. As carbon content rises the metal becomes harder and stronger but less ductile and more difficult to weld. Higher carbon content lowers steel's melting point and its temperature resistance in general.

2.5.1 The American Iron and Steel Institute (AISI)

The American Iron and Steel Institute (AISI) define carbon steel as follows:
Steel is considered to be carbon steel when no minimum content is specified or required for chromium, cobalt, columbium [niobium], molybdenum, nickel, titanium, tungsten, vanadium or zirconium, or any other element to be added to obtain a desired alloying effect; when the specified minimum for copper does not exceed 0.40 per cent; or when the maximum content specified for any of the following elements does not exceed the percentages noted: manganese 1.65, silicon 0.60, copper 0.60.

Carbon steel can be classified, according to various deoxidation practices, as rimmed, capped, semi-killed, or killed steel. Deoxidation practice and the steelmaking process will have an effect on the properties of the steel. However, variations in carbon have the greatest effect on mechanical properties, with increasing carbon content leading to increased hardness and strength. As such, carbon steels are generally categorized according to their carbon content.

2.5.2 Factors in Materials selection

There are a few of how selections of materials are made and the consideration that are involved.

2.5.2.1 Mechanical factor

The factor in this group relate to the ability of the material to withstand the types of stresses imposed on it. These are the mechanical properties of the material that are used as the failure criteria in the design-the strength, the modulus, the fracture toughness, the fatigue strength, creep, and so on. The mode of loading- (such as tensile, compression, bending, and cyclic) dictates which of the properties have the major influence. For example, high strength steels save a lot of weight when stressed in tension, but when they are loaded in bending and stiffness is required ,these materials offer no weight savings over the lower strength grade steels because the

2.5.2.2 Life of component factors

These factors relate to the length of time the materials perform their intended function in the environment to which they are exposed. The properties in this group are the corrosion, oxidation, and wear resistance, creep and the fatigue or corrosion fatigue life properties in dynamic loading. The performance of a material based on these properties is the hardest to predict during the design stage.

2.5.2.3 Cost and availability

In a market-driven economy, these two factors are inseparable. In addition, quantity and standardization are related to cost. Even if the materials are readily available, it matters whether orders are made in pounds or grams.

2.6 THE AUTOMOTIVE ELECTRICAL SYSTEM

The Automotive electrical system does several jobs. It produces electric energy (electricity) in the alternator. It stores electric energy in chemical form in the battery. And it delivers electric energy from these sources on demand to any other electrical component in the vehicle.

The electric energy cranks the engine to start it, supplies the sparks that ignite the air fuel mixture so the engine runs, and keeps the battery charged. These are the jobs performed by the battery, starting, charging, ignition systems and other electric and electronics devices and systems on the vehicle.

The automotive battery supplies electric current to operate the starting motor and ignition system while starting the engine. It also acts as a voltage stabilizer by supplying current for the lights, radio, and other electrical accessories when the alternator is not handling the load. In addition, the battery supplies a small current to the volatile memory in the electronic control module (ECM) while the ignition key is off.

The battery is an electrochemical device. It uses chemicals to produce electricity. The amount of electricity is can produce is limited. As the chemicals in the battery are depleted, the battery runs down and it is discharged. It can be recharged by supplying it with electric current from the vehicle alternator or from battery charger. The depleted chemicals are restored to their original condition as the battery becomes recharged.

2.6.1 Vehicle lighter plug adaptor

Figure 2.8: 12V car cigarette lighter plug adaptor

Figure 2.9: Car cigarette lighter

The car cigarette lighter socket or car adapter that most automobile drivers and passengers are familiar with is properly called a cigar lighter receptacle, since it was originally designed as a lighter for cigars — hence its large size and unheated center that make it less than ideal to light a cigarette.

These sockets were not originally designed to provide electrical power, and are not an ideal power connector for several reasons, notably the fact that three sizes exist (two for 12-volt DC and one for the older 6-volt DC systems) and the mating of the different sized 12 V DC plugs and jacks is problematic. Because of this, and the small-gauge wiring sometimes used, the power connections they provide are sometimes unreliable and not suitable for high-power devices.

Despite these limitations, they are often used for many purposes; for example, electric razors, portable spotlights, laptop computers, mobile phones, PDAs, USB adapters, digital audio players, lamps, or even thermoelectric coolers. For devices that run on regular line voltage, a plug-in inverter will convert to alternating current, and transform it up to 120 or 240 volts AC. Inverters have become so popular that some larger vehicles (minivans, pickup trucks, SUVs, and especially recreational vehicles) come with them built-in, along with domestic AC sockets.

Low-power devices that run on even lower voltages can be plugged into these sockets by using a DC/DC converter. Universal ones have a switch that allows selection of 3, 4.5, 6, 9, and 12 volts. Some instead supply 5 volts to a USB "A" socket, allowing USB devices to be used or recharged. Likewise, the USB socket has become the cigar lighter socket of the computer world, with dozens of unrelated devices now using it for power, especially because of its ubiquitous connector (unlike the many sizes and voltages of coaxial power connectors).

2.7 EQUATION INVOLVED

There are power and torque involve in this project which will be carried out by using these equation in order to find the value needed

Power,

$$P = IV \tag{2.1}$$

The maximum current that can be applied on the motor is 4 A and the voltage is set at 12 Volts

Now to find the Torque of the motor must use this equation base on the revolution of the motor itself,

(2.2)

$$T = \frac{P}{\omega}$$

Number of revolution involved in the gearing system:

$$n_3 = \left|\frac{N2}{N3}\, n_2\right| = \left|\frac{d2}{d3}\, n_2\right| \tag{2.3}$$

Where, capital N is for the number of tooth and small n is for the revolution

Lewis bending stress,

In order to find the bending stress on the tip of gear tooth,

From$\sigma = \frac{MC}{I}$, can get the maximum bending stress

$$\sigma_t = \frac{W_t P_d}{FY} \tag{2.4}$$

Or

$$\sigma_t = \frac{W_t}{FYm} \tag{2.5}$$

Where:

W_t is the tangential load (lbs),

P_d is the diametral pitch (in-1),

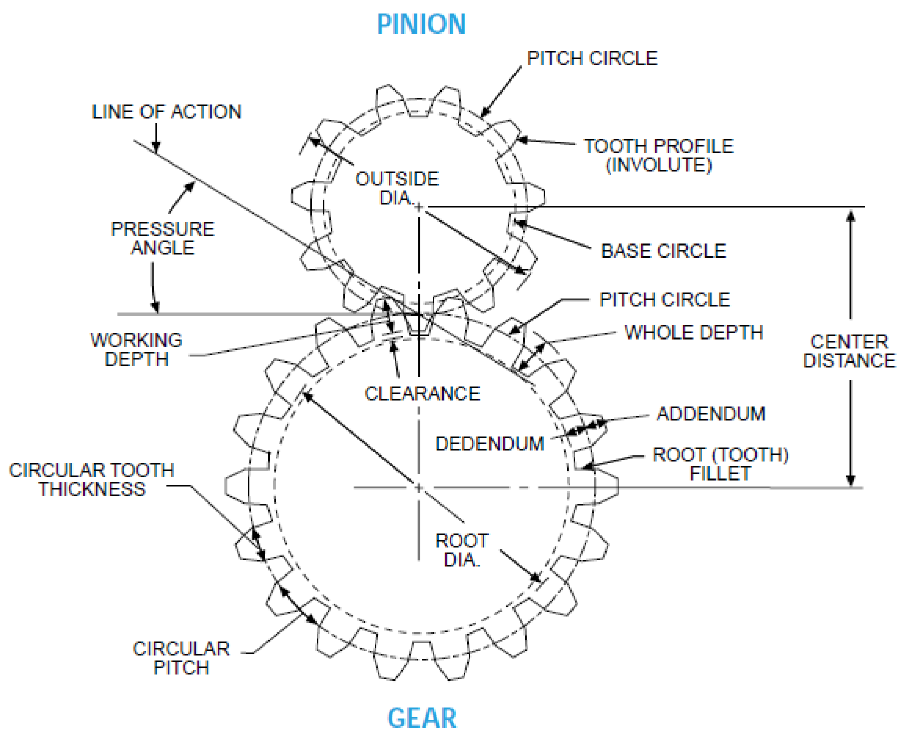
F is the face width (in), and

Y is the Lewis form factor (dimensionless)

m is the module

2.8 GEARING SYSTEM

In this project, gearing system is crucial in order to increase the torque for the motor. This is due to support more torque on the shaft. The typical spur gear is presented:



- Diametral pitch (d_p)...... The number of teeth per one inch of pitch circle diameter.
- Module. (m) ...... The length, in mm, of the pitch circle diameter per tooth.

- Circular pitch (p)...... The distance between adjacent teeth measured along the are at the pitch circle diameter
- Addendum (h_a)...... The height of the tooth above the pitch circle diameter.
- Centre distance (a)...... The distance between the axes of two gears in mesh.
- Circular tooth thickness (ctt)...... The width of a tooth measured along the are at the pitch circle diameter.
- Dedendum (h_f)...... The depth of the tooth below the pitch circle diameter.
- Outside diameter (D_o)...... The outside diameter of the gear.
- Base Circle diameter (D_b) ...... The diameter on which the involute teeth profile is based.
- Pitch circle dia (p) ...... The diameter of the pitch circle.
- Pitch point...... The point at which the pitch circle diameters of two gears in mesh coincide.
- Pitch to back...... The distance on a rack between the pitch circle diameter line and the rear face of the rack.
- Pressure angle...... The angle between the tooth profile at the pitch circle diameter and a radial line passing through the same point.
- Whole depth...... The total depth of the space between adjacent teeth. Plain-Carbon Steels Good machining, can be heat treated Power gears with medium rating to commercial/medium quality

2.9 EXAMPLE OR RESEARCH

2.9.1 Research by Yang-chou Liu (1997)

Work done by Yang-chou Liu (1997), it is obvious to those skilled in the art that in a conventional threaded car jack, the piston is replaced by a threaded shaft which is lifted or lowered by a rotating action. A typical car jacks have a common disadvantage that they cannot prevent an unintentional lowering thereof when they are supporting a lifted heavy load, for example a car. This is particularly true for the hydraulic car jack since a hydraulic driving mechanism is more unreliable than a threaded driving mechanism although the former is more convenient and easier to operate. An unintentional lowering of the car jack is very dangerous to the driver who may lift front or rear wheels of the car and crawl into an underside of the car to carry out maintenance or repairs. Thus, many conventional car jacks having operating manuals clearly required the driver, when using a car jack like the car jack to lift front wheels of a car as indicated by phantom lines of the present application, should also use a fixed supporting stand to support the car, thereby to avoid the danger caused by an unintentional lowering of the car jack. However, in fact, most drivers will not spend extra money to buy the fixed supporting stand when they are purchasing the car. Rather, in many cases, they prefer to use a stack of bricks to support the lifted car. Such a support by a stack of bricks is not secure and sometimes may cause a catastrophe. Further research needed such as locked as any desired lifted level thereby to prevent an unintentional lowering of a heavy load, for example, a car supported by the present invention.

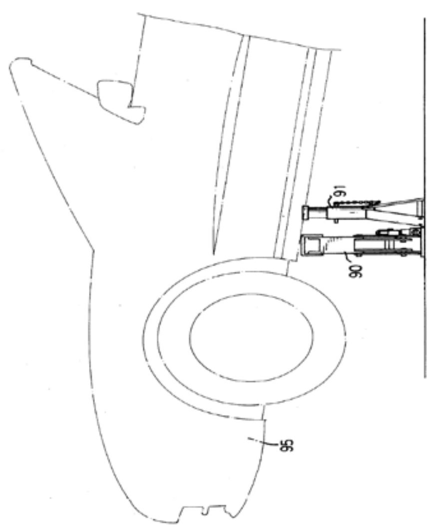


Figure 2.10: Stand after jacking the car jack to a certain level

2.9.2 Research by Edward M.Lonnon(1992)

For example, work done by Edward M.Lonnon specified on a motorized jack assemblage for vehicles which use the form of kit containing a motor and reduction gear linkage adapted to be energized from the cigarette lighter or other source of electrical power in the vehicle. The gear linkage is adapted to drive mechanical coupling means, which keys into and operates a lift jack, which in one case is part of the standard equipment for the vehicle, and in another case is a jack with a specialized base which is part of the kit. The type of motorized jack presently available on the market has certain disadvantages, in that it is hard to be carried and to use, and is not readily disassembled to be carried or stored. Furthermore, it is not adapted for use with a standard jack of the type which is furnished by the manufacturer of certain types of vans. Accordingly, it is the principal object of this invention to provide a kit for a motorized jack assemble which is readily assembled and disassembled for storage and transport. A more particular objective of the invention is to provide means for collaborating with a type of jack which is conventionally furnished as standard equipment for certain types of vans, which when the jack is applied to the rear axle or bumper of a vehicle, may be operated electrically to enable the vehicle to be raised quickly and conventionally, with minimum effort on the part of the operator. The extra features of the kit of the present invention are two small lamps mounted on the supporting base. One lamp in a rectangular housing, powered from the car battery, is hinged connected to one edge of the supporting plate, next to the jack emplacement. This lamp is rotatable to an upward facing position to throw a light beam on the underside of the vehicle during the jacking operation. The other lamp, battery powered, is an elongated signal lamp, cylindrical in form, removable secured in a clamp along the opposite edge of the supporting plate. The signal lamp is adapted to be removed from its clamp to be used for signaling purposes during the jacking procedure.

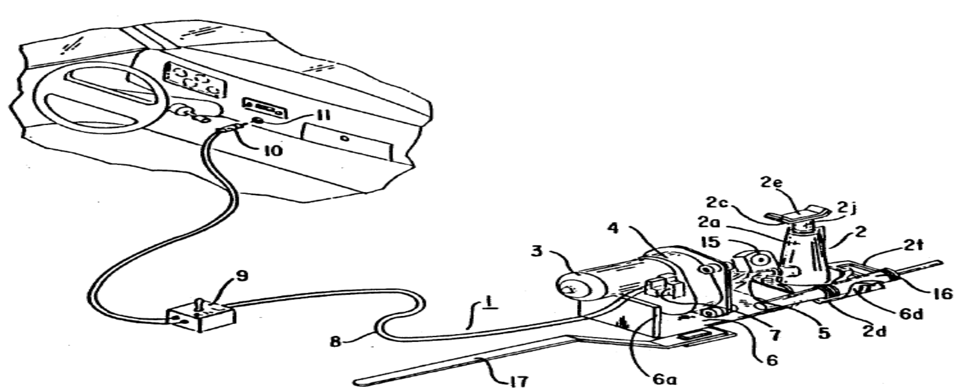


Figure 2.11: Motorized jack assembly kit

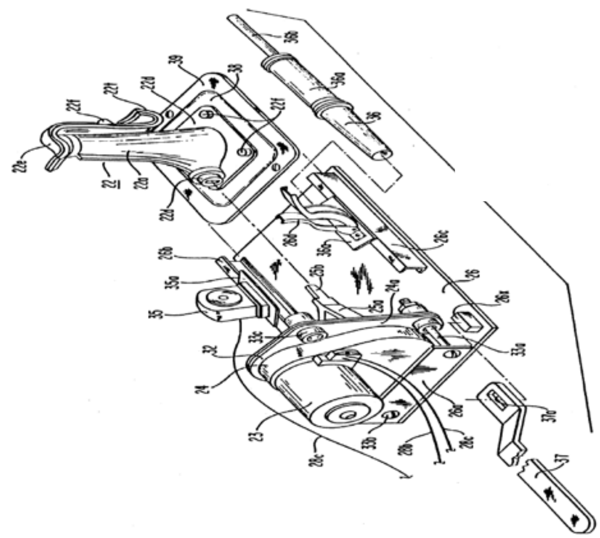


Figure 2.12: Shows a perspective view of the components of the motorized jack assembly kit, in the process of being assembled.

Base on this patent done by Edward M.Lonnon (1992) the screw threaded and gear linkage are not suitable because there is more downwards force from the weight of the car. Thus, a failure on the gear or threaded system will occur and obviously will cease the jack to work properly.

In determining shaft and bearing loads for bevel gears applications, the usual practice is to use the tangential or transmitted load that would occur if all the forces were concentrated at the midpoint of the tooth. The force acting at the center of the tooth has three components; a tangential force W_t, a radial force W_r, and an axial force $W_{a.}$

Fatigue wear is caused when the surface of the gear is subjected to cyclic loading. The wear particles usually formed through stalling or pitting. Cracks on the surface are generated by thermal stresses from the thermal cycling.

2.9.3 Research by Farhad Razzaghi (2007)

In another example, work done by Farhad Razzaghi (2007), an apparatus and method for an electric jack, wherein an electrically powered jack is provided for at least partially raising and lowering an automobile off a ground surface. The apparatus may be utilized in conjunction with a conventional portable car jack, wherein the apparatus comprises a power drill and a rod. Each jack adapter is specifically to attach to a particular type of carjack, thus providing an apparatus that may be utilized with an assortment of car jacks. However, previous jacks nevertheless suffer from several inherent structural and functional limitations. In general, conventional electric jacks are only suitable for use with automobiles that are designed by a particular car manufacturer. These are due of large number of imported cars from foreign countries. As such, a jack that is adapted for use with Chevrolet truck may not function properly to lift a Mercedes Benz sedan. Such a disadvantage is especially burdening some people who own more than one car or who prefer to switch automobiles on a frequent basis. In addition to the difficulties in assembling and setting up electric jacks, such jacks are generally not adapted to be readily disassembled and stored after the automobile repairs have been completed. Therefore, it is readily apparent that there is a need for an apparatus and method for an electric jack that eliminates the heavy task with the use and application of conventional manually-operated jacks. There is still a further need for such an apparatus and method that is adapted for use with automobile.

In yet further alternative embodiment, tool could compromise a light-emitting source for illuminating a work area in dimly-lit settings or at night. Moreover a jack adapter could be permanently fixed to rod.

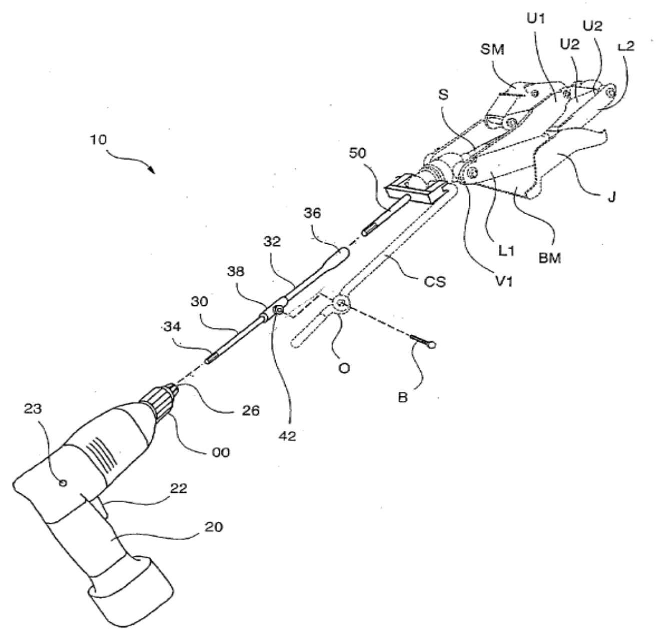
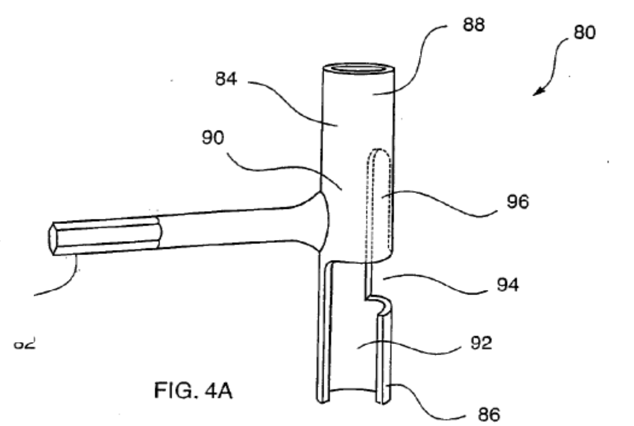


Figure 2.13: Shows a perspective view of an apparatus for an electric jack according to a preferred embodiment of the present invention.



Figures 2.14: Show a perspective view of car jack adapters of an apparatus for an electric jack according to a preferred embodiment of the present invention.

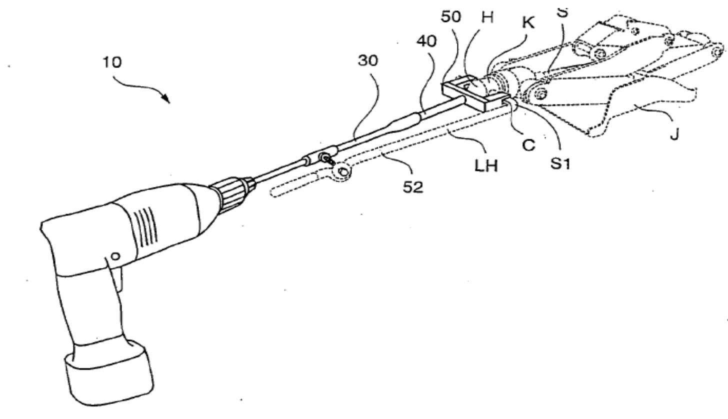


Figure 2.15: Shows a perspective view of a car jack adapter of an apparatus for an electric jack according to a preferred embodiment of the present invention.

2.9.4 Research by Kevin Andrews

Research by Kevin Andrews which entitled, electrical automobile car jack is described. A typical embodiment includes a base frame or housing that is adapted to be placed on the ground underneath the automobile to be lifted. The housing includes motors connected to drive arms connected to a load bridge and plate. The bridge is typically mounted within the drive arms by rids located within slots on the arms enabling the bridge to move upward and downward while being retained within the drive arms. Typically, the motors are operated by the car's battery the drive arms typically include drive wheels that rotate oppositely and are coupled together by a coupler moves uniformly. The motors drive the arms, lifting and lowering the load bridge which lifts and lowers the automobile. The jack can be operated by remote control.

One advantage of the invention is that it can be placed underneath an automobile then can be operated remotely and electrically while the operator stands comfortably away from the vehicle. Another advantage of the invention is that it can be powered from presently available electrical power from the vehicle. Moreover, it includes two drive sections that can be coupled together to stabilize the jack load.

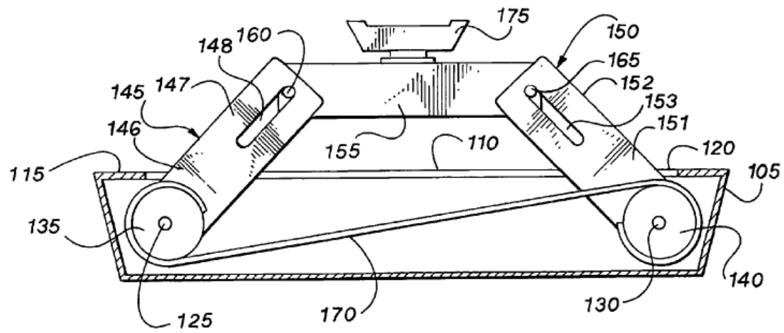


Figure 2.16: Design by Kevin Andrew

2.9.5 Research by Charles F. Sweeney (1995)

Research by Charles F. Sweeney on pneumatic car jack is described. A jack structure wherein a rigid housing includes a plurality of stacked pneumatic bags within housing, wherein the stacked pneumatic bags are arranged for selective inflation by use of a pneumatic compressor that in turn is operative through an electrical supply line that is arranged to receive electrical energy from the cigarette lighter or have clips to attach to positive and negative terminals of car battery of an associated vehicle. A valve assembly permits selective inflation and deflation of the pneumatic bag structure within the housing.

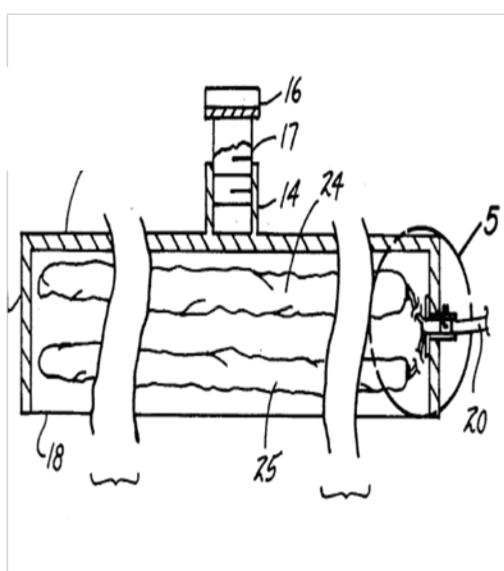


Figure 2.17: Design by Charles F. Sweeney

CHAPTER 3

METHODOLOGY

3.0 INTRODUCTION

This chapter will be about what are the steps and development that need to be worked on to complete this project and to achieve all the objectives. Several steps had been planned and set to make sure the project will go on through the right path. The flow diagram is attached in this chapter. First of all according to the flow diagram, the project will start on finding the current design of various car jacks available in the market since it is going to give a lot of ideas. Next, study the concept of all the car jacks with references from the books and internet available. Furthermore, draft of sketch the new design with improvement on current design. The next process is design approval from the supervisor before proceed to another step. The next step is involving the use of Solidworks 2007 software to transfer from the sketch design into the software. The completed design in Solidworks 2007 is then change the type of the file into IGES file and open in the ALGOR software for the FEA (analysis) to look the strength of the design and frame body. Moreover on the next step is to select the correct material that involve in this project. After that, assemble and joint will take place where involving cutting, assembling and joining the raw material. When everything is completed, the performance of the automatic car jack powered by internal car power is tested.

3.1 METHODOLOGY FLOWCHART

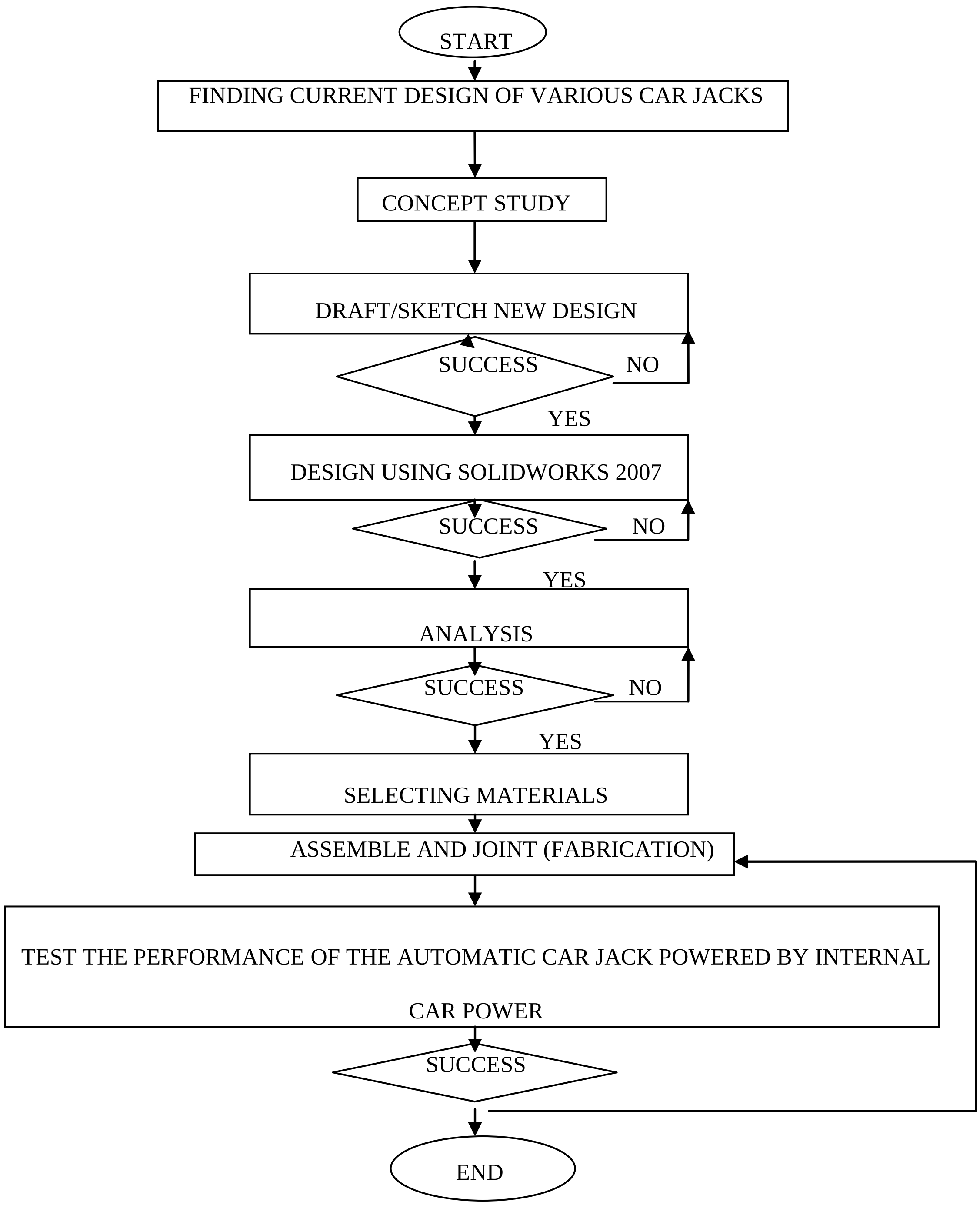


Figure 3.1: Methodology flowchart

3.2 FINDING CURRENT DESIGN OF VARIOUS CAR JACKS

In finding the current design of various car jacks, the important thing is the needs of easier brainstorming the ideas from available design into a new design with some improvements. Some car jacks available such as floor jack, hi-lift jack, hydraulic jack, pneumatic jack and scissor jack. All the jacks perform in different way but similar method which is to lift or raise the vehicle.

After knowing all current designs of various car jacks, a study on a suitable type of car jacks is needed.

3.3 CONCEPT STUDY

In this area, a study on hydraulic and scissor jacks is the most important since it is the basic and suitable to apply on this project. Furthermore, sample of scissor and hydraulic jacks are observe to see more details on how it really works and what it required to develop those type of jacks. In addition, the concept is mainly about to raise the vehicle and follow the objectives and scopes that are set. All the concepts are studied base on all the journals.

3.4 DRAFT/SKETCH NEW DESIGN

The next process would be draft or sketched the new design of the automatic car jacker powered by internal car power. The new design basically, base on the frame that has good strength ability to withstand a massive load below 1000kg.Furthermore,all the sketches will be viewed, stored and will be decided to show to the supervisor for approval. If there is any problem occurs during the sketch, a new sketch will be carried out again. Redesign the sketch is important. Something that is redesigned requires a different process than something that is designed for the first time. A redesign often includes an evaluation of the existent design and the findings of the redesign needs are often the ones that drive the redesign process.

3.5 DESIGN APPROVAL

In this step, it is crucial to get the approval design from the supervisor in order to progress to next step which is to transfer the design into Solidworks software. The supervisor must give a strong recommendation if something wrong with the approval of the design.

3.6 DESIGN USING SOLIDWORKS 2007

After the design is approved by the supervisor, the right dimensions and shape is design in Solidworks 2007.The design should be the same with the sketch and only minor change is allowed if something wrong to design each part occurs. In this software, a design part by part is done to make it easier for assembling.

3.7 ANALYSIS USING FEA (ALGOR)

In this step, the completed design from the Solidworks 2007 is transferred to ALGOR software but first, the type of the file must be changed to IGES file. At first, take the whole design and set the material that will be used, percentage of the mesh and then analyze it to see the stress, strain, displacement and the most important thing is it should withstand the load about 300kg in a static motion. If failure occurs in the loading method of bending, different material can be used and set again in the material selection part. Then, new analysis must be done.

3.7.1 Linear Static Analysis

Linear static analysis allows designer to test different load conditions and their resulting stresses and deformation. Knowing how a design will perform under different conditions allows us to make changes prior to physical prototyping, thus saving both time and money.

Linear analysis allows design engineers and analysis experts to perform basic stress analysis of simple models or complex 3D assemblies. The program produces displacements, strains, stresses, forces, and error estimates as results of the analysis under a variety of loading conditions.

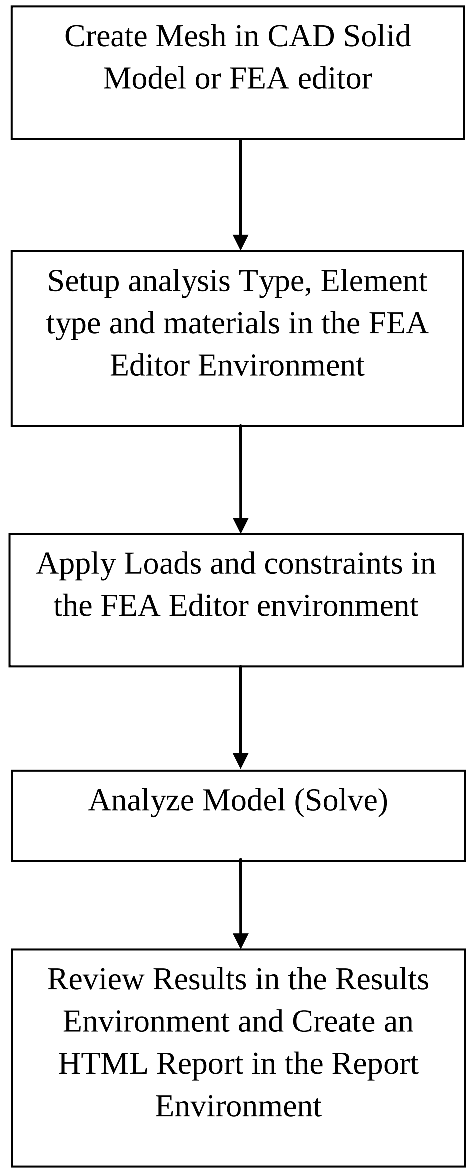


Figure 3.2: General Procedure of FEA using ALGOR

3.7.2 Build/Mesh Model

Retrieve the part file and bring it into the CAD Solid Model environment. From the CAD Solid Model environment, we will go through FEMPRO's surface and midplane meshing. In this process, the surfaces loaded previously area meshed into a number of elements with a certain number of nodes. Issue selects the shape rectangle and vertices command to select the surface need to be loaded force in order to select the boundary conditions.

3.7.3 Element and material type

Element Type and Material in the FEA editor is used to define all elements and material groups. Different finite elements types, such as bricks (Solids), Shells (plates) and beams (lines), can be used together to analyze the same model. Besides that different type of materials also can be used to choose type of the material such as steel, aluminum and etc. The choice of the elements and materials used depends on the physical make up of the body under actual loading conditions.

3.7.4 Load application

Uniform pressure is applied on the surface of the car jack and between the mating gears where the analysis took placed. Applied pressure would produce a bending condition with maximum stress occur at the place has highly possible to fail.

3.7.5 Analyze model

After loads applied to the surfaces of the parts, the next step was to perform the analysis. The model's deformation, displacement, strain and stress are viewable simply by clicking an area of the model the result can be automatically saved in HTML format or PDF.

3.8 SELECTING MATERIALS

The next step is selecting materials. The materials that have been discussed with the supervisor are collected such as power window motor, mild steel, hydraulic jack and others. The materials must be in good condition and if it is from the junk yard or lab, the material still working or can be used. Choosing the right material is important due to reduce the weight and increase the safety features of the car jacks. Moreover, in this section the electrical parts for controller will be made for the power window to work clockwise and counter-clockwise.

3.9 ASSEMBLE AND JOINT

In this section, development of a real car jacker is performed. Assemble and joint according to the design and in this part, work must be done carefully since it involving machineries. The machines that will be used are EDM wire cutting, stand drill, grinder, welding machine, shear machine, bending machine. All the safety aspects must be taken seriously. The fabrication process involve all steps in order to fabricate the product starting from cutting process of various shapes of metals (sheet metal and tube metal) until the fabricated metal prepared to be assembled. There are several processes that will involve in this project.

3.10 TEST THE PERFORMANCE OF DEVELOPED AUTOMATIC CAR JACKER

The last section of this project would be testing it on a car (kancil) because kancil has the appropriate weight (682 kg) to be tested on the developed jack. The electrical part which is connected into the cigarette lighter is checked and then the switch that controlled the auto car jacker is operated. If the car jacks can be operated properly and raised the car without any failure, the test and project is considered successfully.

3.11 DOCUMENTATION

In this section, after finishing all the fabrication process and the final product is completed, all the documentation regarding the result will be finished and will be as a thesis for reference in the future.

CHAPTER 4

RESULTS AND DISCUSSIONS

4.0 INTRODUCTION

In this section, all the calculations and results that obtained for this project is presented. The result is then to be discussed which will fully be used for this project. It is important to do analysis before proceed on fabricating the model because it can give an initial or first result on the real model.

4.1 DISCUSSION ON FINALIZED AND COMPONENTS SELECTION

4.1.1 Weight

Weight or mass residing in the parts must be small as possible as it must be proven to be low in weight so that easier to carry the jack. The parts which used the material for fabrication is for the power window motor holder, car jack stand and the most crucial part are the gears which will be involved a lot of forces. The material that has been identified to build the automatic car jack parts was carbon steel A-36 because it was proven for:

- Most popular material for original part of a scissor jack
- Easier to obtain in FKM lab
- Can be welded or bonded easily
- Strong
- Rigid

- Resistance from impact
- Strong enough to fix components easily
- Easy to machine

Applications of the materials: Shafts, lightly stressed gears, hard wearing surfaces, pins, chains.

From the current research and application used internationally, the material is suitable and can be used as part of the fabrication material process.

The assumed weight for the designed automatic car jacker using internal car power is less than 7 kg without considering the battery. After the fabrication process the weight of the developed car jack is only about 4.6 kg. It is less than the assumed weight by 2.6 kg.

4.1.2 Motor selection

Electric motor is the main part of the system which involving it to rotate clock-wise and counter clock-wise so that the scissor jack can easily be raised and lowered with two buttons system. The motor that has been selected for the project is BOSCH power window motor which is the best power window motor in term of type, torque and reliability. The torque that has been calculated for the motor is 5.877 Nm which then be increased by a gearing system.

4.1.3 Battery

For the designed automatic car jacker powered by internal car power it used battery of lead-acid type provide a nominal 12-volt potential difference by connecting six galvanic cells in series. Since the cells naturally produce about 2.1 V each, the actual voltage is roughly 12.6 V (2.1 x 6 = 12.6V) at full charge. The battery power is sufficient to power the power window motor which according to the motor specification it used 12V-DC power supply.

4.1.4 Dimensions and final design

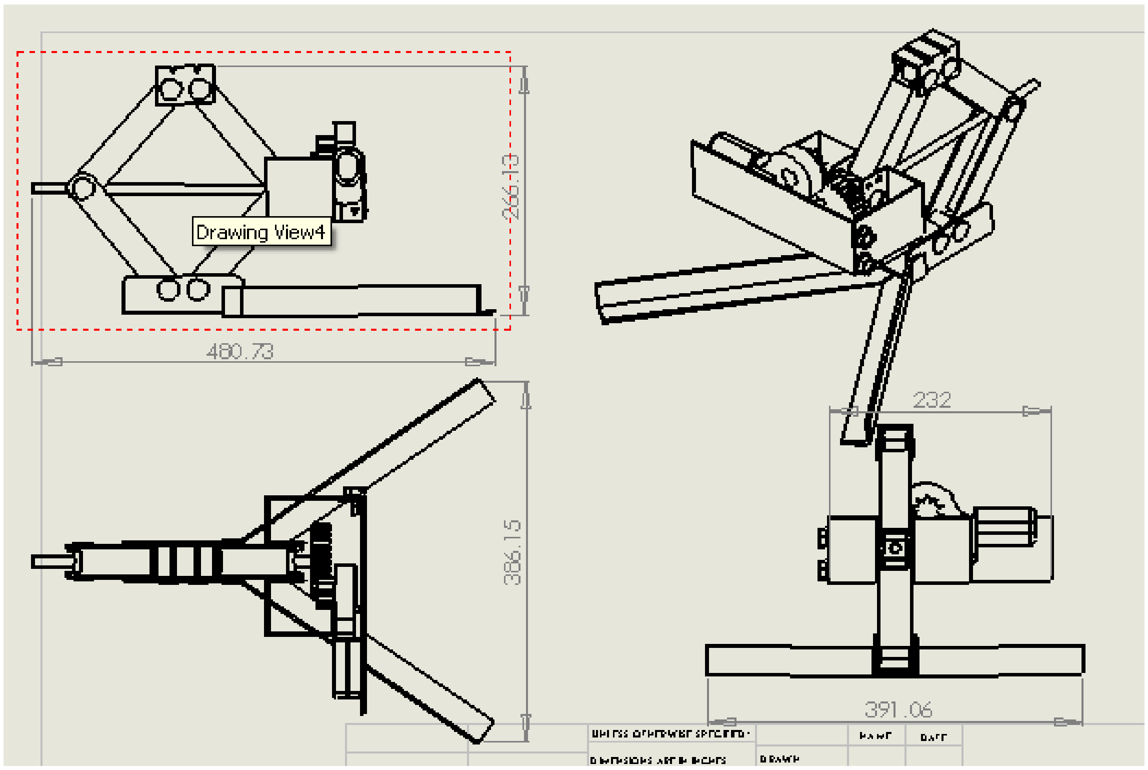


Figure 4.1: Dimensions

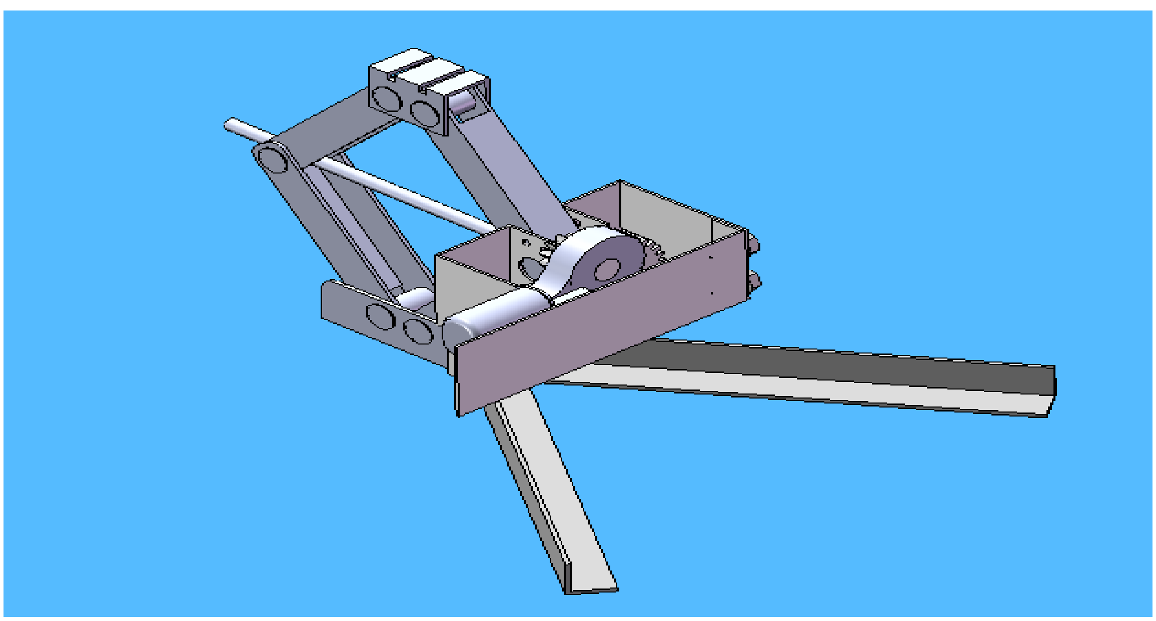


Figure 4.2: Final Design

Figure 4.3: Actual Prototype

4.2 THEORETICAL CALCULATION ON SPUR GEAR

This is calculation to find the value to make spur gear. The values that need to find is diametral pitch, base circle, addendum, addendum diameter, dedendum, and dedendum diameter from diameter pitch value and the value of the tooth have been set.

For gear with 30 tooth (Diameter Pitch = 76.2 mm),

Diametral pitch, $Pd = \frac{N}{d}$

$=30/76.2$

$=0.3937\ mm^{-1}$

Module, $m = \frac{d}{N}$

$= 76.2\ /30$

$= 2.54$ mm

Circular Pitch, $P = \frac{\pi}{Pd}$

$= \pi / 0.3937$

$= 7.979$ mm

Base circle, $d_b = d \cos \alpha$

$= 76.2 \cos 20$

$= 71.605$ mm

Addendum, $a = \frac{1}{Pd}$

$= 1/0.3937$

$= 2.54$ mm

Addendum Diameter, da = d+2a

$= 76.2 + 2\,(2.54)$

$= 81.28$m

Dedendum, $b = \frac{1.25}{Pd}$

$= 1.25 / 0.3937$

$= 3.175$ mm

Dedendum Diameter, db = d – 2b

$= 76.2 - 2\,(3.175)$

$= 69.85$ mm

Clearance, c = b – a

$= 3.175 - 2.54 = 0.635$mm

For gear with 10 tooth (Diameter Pitch = 25.4 mm)

Diametral pitch (Pd) is the same with 30 tooth gear.

Pd = 0.3037 mm^{-1}

Diametral Pitch, $Pd = \frac{N}{d}$

= 10/ 25.4

= 0.3037 mm^{-1}

Circular pitch, $P = \frac{\pi}{Pd}$

= π / 0.3937 =7.9797 mm

Module, $m = \frac{d}{N}$

= 25.4/ 10

=2.54 mm

Base circle, $d_b = d \cos \alpha$

= 25.4 cos 20

= 23.87 mm

Addendum, $a = \frac{1}{Pd}$

= 1/ 0.3937

= 2.54 mm

Addendum diameter, da= d + 2a

= 25.4 + 2 (2.54) = 30.48 mm

Dedendum, $b = \frac{1.25}{Pd}$

= 1.25/ 0.3937

= 3.175 mm

Dedendum diameter, db = d- 2b

= 25.4 – 2 (3.175)

= 19.05 mm

Clearance, c = b – a

= 3.175 – 2.54

= 0.635 mm

4.2.1 Module (m)

The module is the ratio of the pitch diameter to the number of teeth. The unit of the module is millimeters. Below is a diagram showing the relative size of teeth machined in a rack with module ranging from module values of 0.5 mm to 6 mm

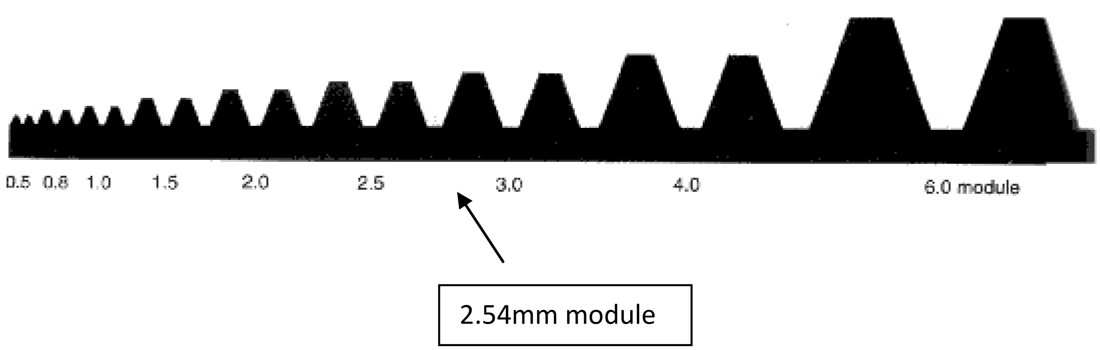


Figure 4.4: Shows a module diagram ratio of the pitch diameter to the number of teeth

The preferred module values are

0.5 0.8 1 1.25 1.5 2.5 3 4 5 6 8 10 12 16 20 25 32 40 50

The module of the gears that are used is 2.54mm.So the range for the gears is in the middle of the diagram.

4.3 SPECIFICATION OF SPUR GEAR

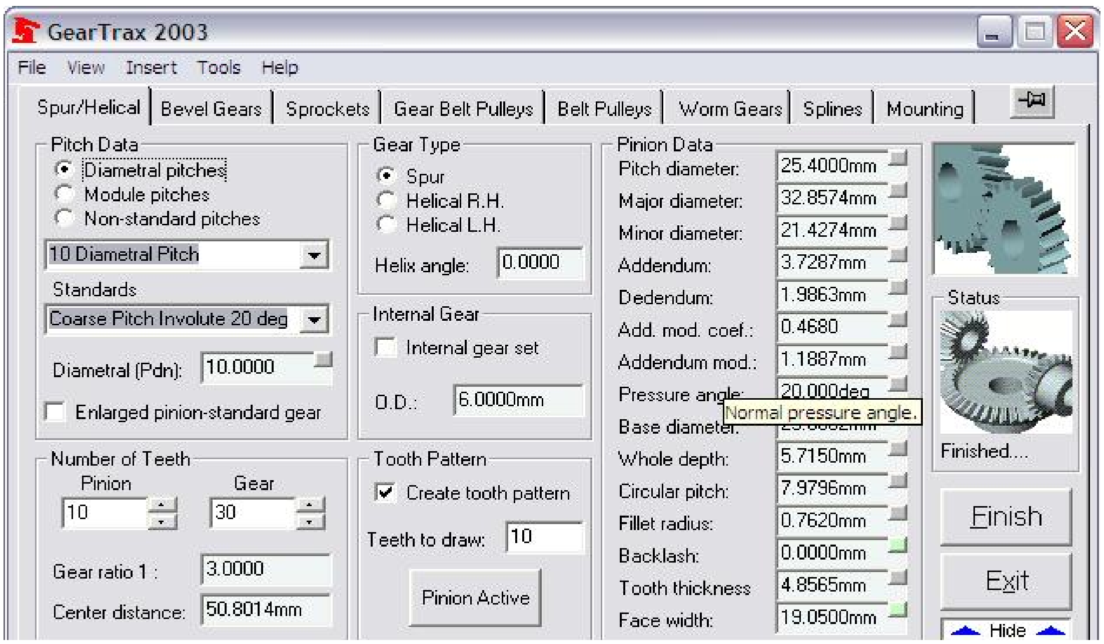


Figure 4.5: Specification pinion gear 10 teeth

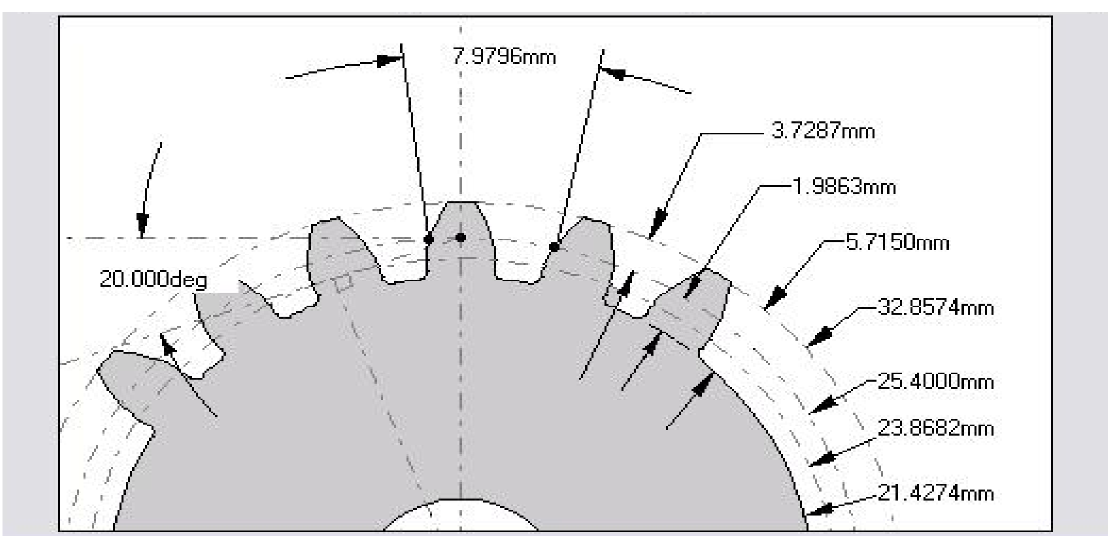


Figure 4.6: Drawing for pinion gear 10 teeth

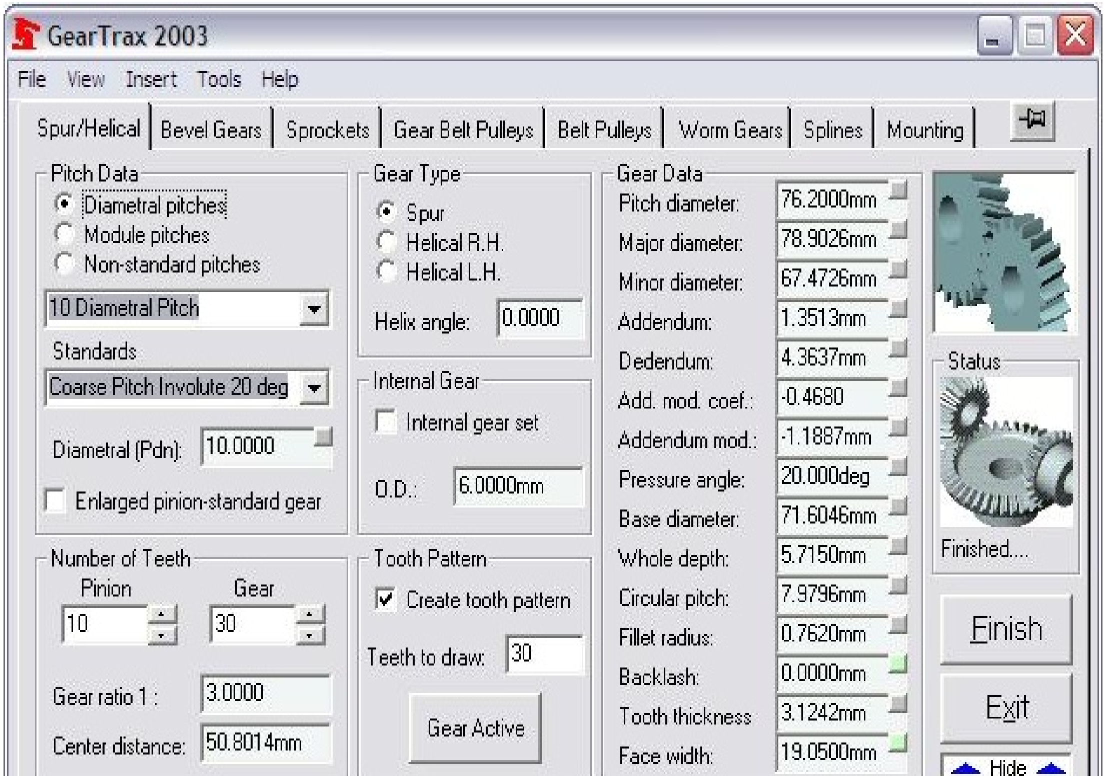


Figure 4.7: Specification gear 30 teeth

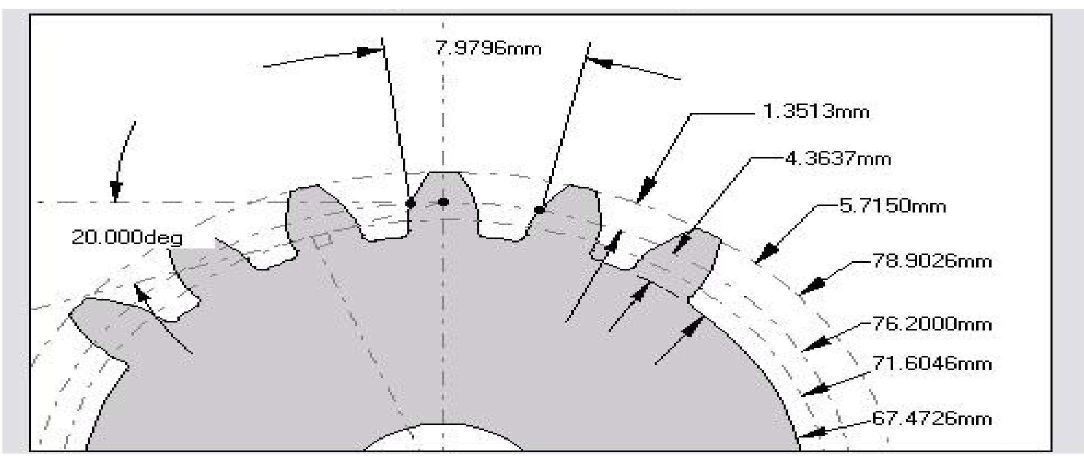


Figure 4.8: Drawing for gear 30 teeth

Figure 4.2 and figure 4.4 show the specification of pinion and gear. The specification obtained from the Gear Trax 2003 Software. The values that must be put in this data are type of gear, diametral pitches, coarse pitch degree and number of teeth pinion and gear. All the data are shown after running the program. The values are than compared with the manual calculation. The comparisons are almost the same and proceed to the next stage.

4.4 MOTOR PERFORMANCE

Table 4.1: Table of motor's performance

Volt (v)	RPM
6	33
8	42
10	60
12	78

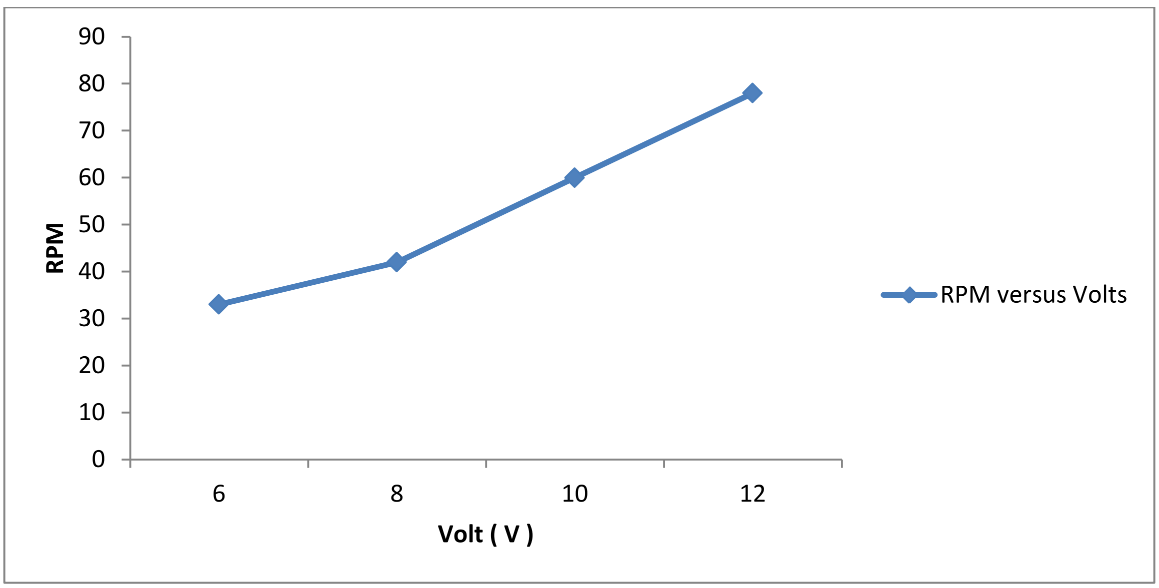


Figure 4.9: Graph of RPM versus volts.

From the table 4.1 and the graph 4.6, it shows that the rpm (revolution per minute) increased within the Volt. In this section the volt is set as variables while the current is set as constant at 4 amps. For the project, 12 volts DC is used because in the car battery the maximum volt is 12 V while 4 amps current is used according to the motor specifications. The calculation of the power, force and torque are based on the 78 rpm.

4.5 STATIC ANALYSIS

In this section, ALGOR software is used to determine either the analysis show the failure when optimum force is applied on the scissor jack on the gears and on the scissor mechanism. The scope for the weight of the car is about 682 kg for kancil's car which equal to 6690.42 N if the gravity taken under consideration is 9.81 ms^{-2}.In the analysis on the scissor mechanism, the weight will be a variable factor which 2943N (300kg) will be the maximum weight under consideration because when a car is jacked on one point the point will be less than the weight of the car since the car have other parts such as tires, springs and absorber which in this case will be ignored.

In this section, only upper part of the scissor jack will be analyze because the shape are the same with the lower part of the scissor jack. Furthermore, in ALGOR software it is much easier to analyze a simple model rather than complicated model. The force will be on the head of the jack where the load will be a distribution load.

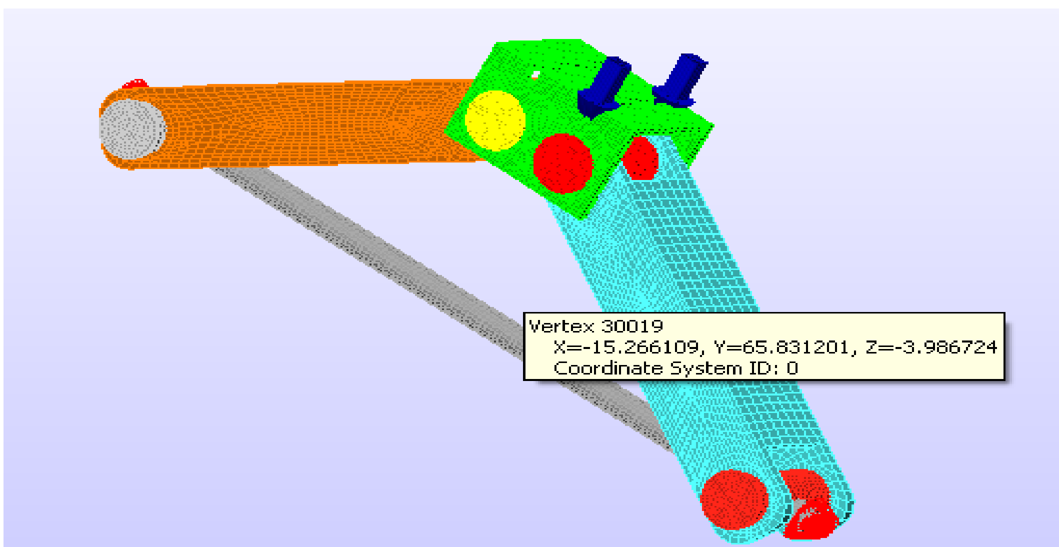


Figure 4.10: Shows the fixed point and the load applied on the system analysis

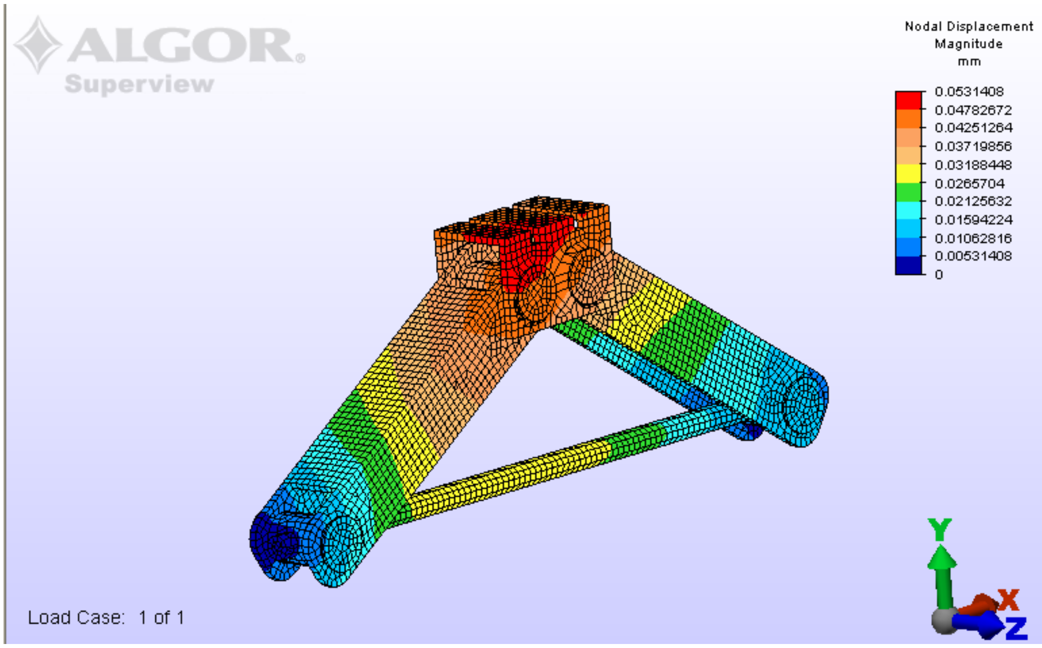


Figure 4.11: Nodal displacement

In Figure 4.11, it shows the nodal displacement value for the upper jack part which is from the FEA analysis, the maximum result is 0.0531408mm which is when load of 300kg is applied. The difference is too small which can considered the deflection is safe condition.

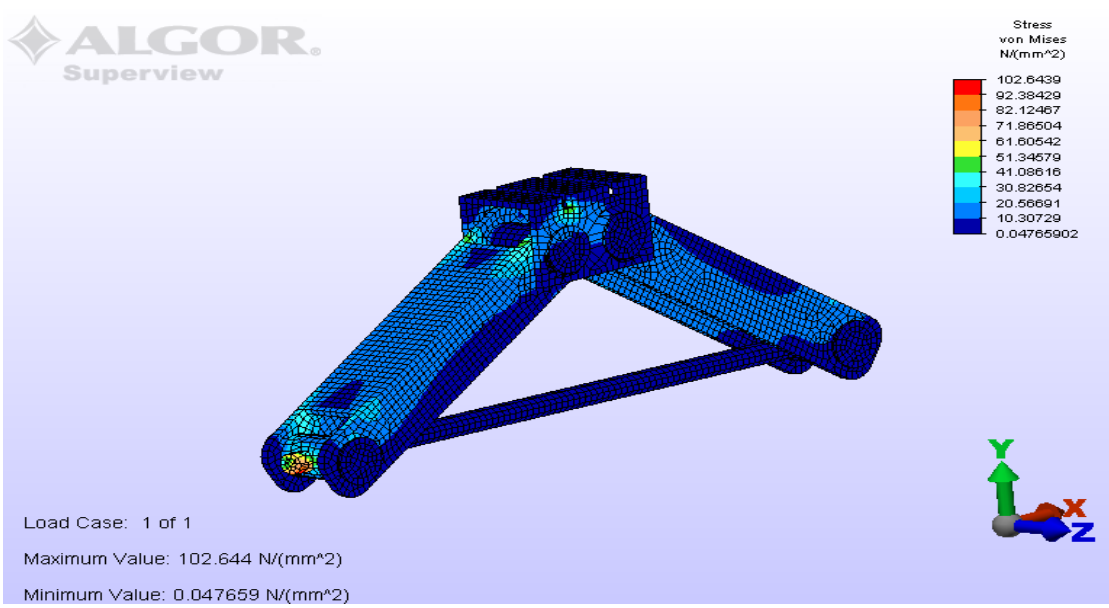


Figure 4.12: Stress Von Mises

Furthermore, base on Figure 4.12, it shows the Stress Voon Mises value which is obtained from FEA. It shows that the maximum value for Stress Von Mises for the upper jack part is 102.644 Mpa. The value will be discussed base on the graph curve and comparison with the material properties.

Table 4.2: Load varies with Stress Von Misses and Nodal displacement

Load (N)	**Stress Von Misses (N/mm2)**	**Nodal Displacement Magnitude (mm)**
490.5	17.10732	0.0088568
981	34.21464	0.0177136
1471.5	51.32196	0.0265704
1962	68.42928	0.0354272
2452.5	85.53661	0.044284
2943	102.6439	0.0531408

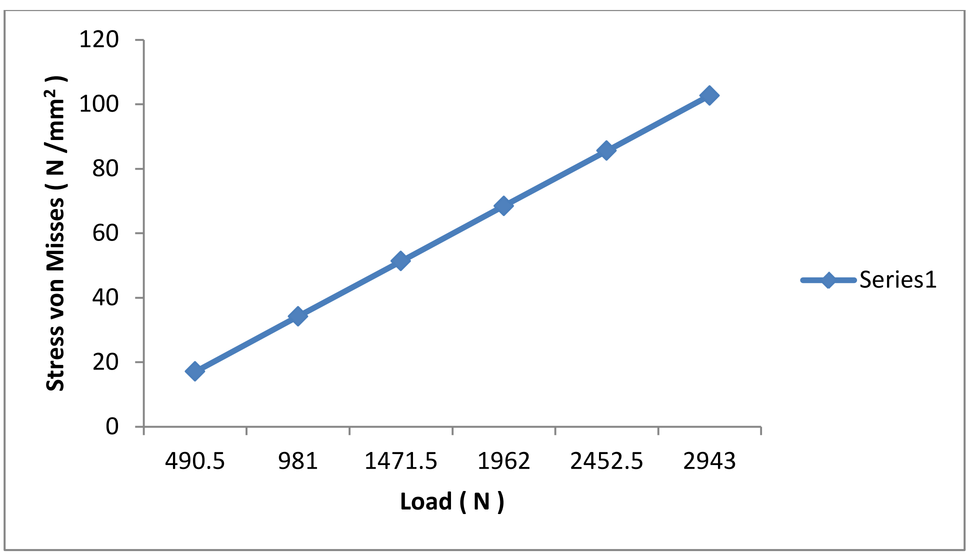


Figure 4.13: Graph of Stress Vs Load

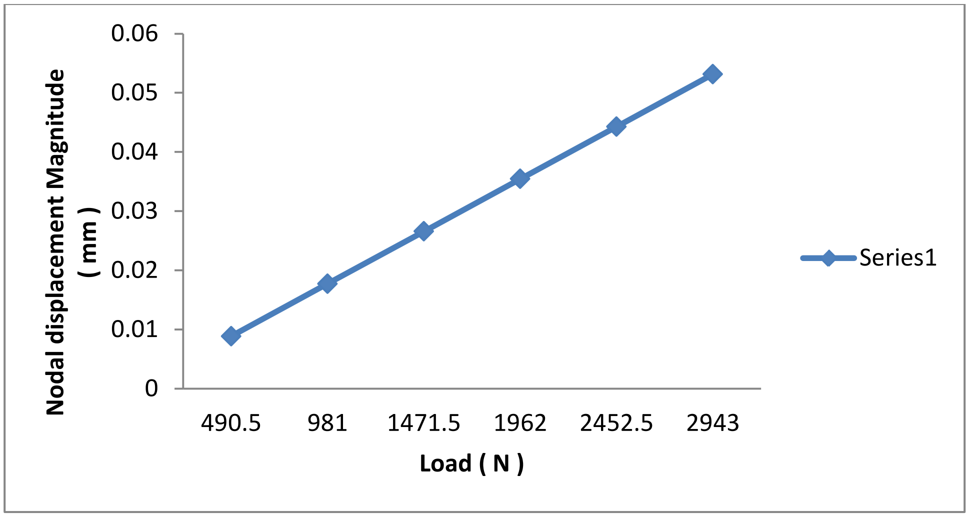


Figure 4.14: Graph of Nodal Displacement Magnitude Vs Load

Base on the analysis on FEA ALGOR, it shows that the maximum nodal displacement magnitude on the system car jack is only about 0.053mm with maximum load applied is 2943 N which is equal to 300 kg. So, it is considered as a safe jack. The material that have been tested on this software is low carbon steel A-36.Moreover, from the curve of the graph it is a linear function which will increase along the y-axis within the increment of load.

Furthermore, from the analysis on Stress Von Misses, the maximum value is 102.6439N/mm^2 which can be stated that it is still safe because the $\sigma_{vm} < \sigma_y$ .Stress, σ_y for low carbon steel is 250 MPa.

4.6 TORQUE OBSERVATION

Observation on Torque vs. Height

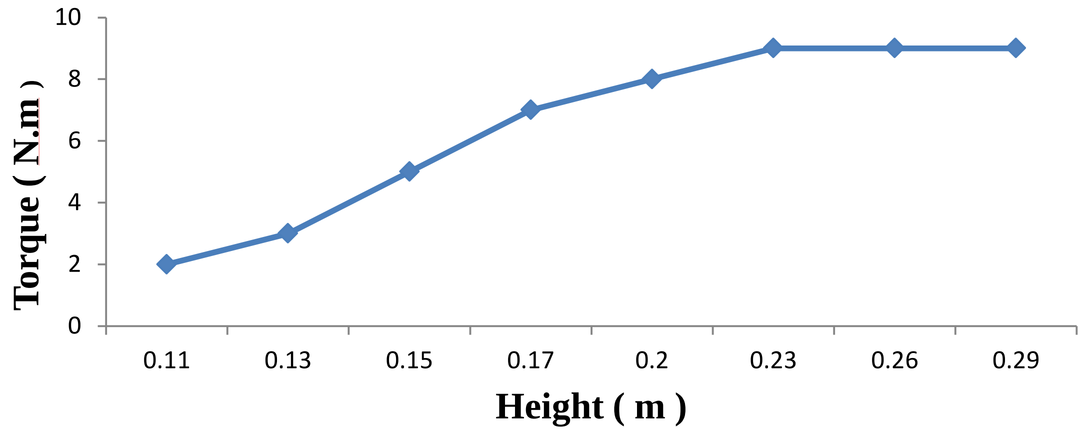


Figure 4.15: Graph of torque versus height

Table 4.3: Height and Torque data

Height of head load from the ground (m)	Torque needed (N.m)
0.11	2
0.13	3
0.15	5
0.17	7
0.20	8
0.23	9
0.26	9
0.29	9

From the graph 4.15, it shows the flow of the torque needed base on the differentiation of height. The torque increased within the height of the car jack's head load from the ground. The height is measured on a specific car which is a kancil 660cc car (PDL 146).The actual car height from the ground to the base of the car is 0.13m.The torque needed is obtained from the method of using the torque wrench which is inserted into the shaft of a scissor jack. Base on the observation done on the lifting torque by using normal scissor jack, at a certain height of 0.11m, the torque needed is 2

N.m. At a height of 0.15, the car is being lifted with the support of the jack and from the torque wrench gauge, it shown the torque increased to a 5N.m value. The torque is increased within the height until at a certain point which is at 0.23m where the torque maintained the value to 9N.m until 0.29m.The proper maximum height to lift this specific kancil car is 0.29m.From the observation, the actual torque needed can be calculated and transferred onto the mechanism gearing system. The maximum torque needed from the observation is 9 N.m so the calculated and developed automatic car jack must exceeded the 9N.m value for the system to be able to lift a kancil car. The test lifting point is constraint at only one point due to obtain the best result.

4.7 ANALYSIS OF SPUR GEAR

In this section, the gears used are analyzed. It is analyzed using theoretical and then can be compared with the FEA model result.

4.7.1 Force analysis

The forces that are mating on the gears are to be determined.

The values that needed to find is the force at mating gear and force from the torque value that already have from the motor.

Power, P = IV

From equation 2.2, the maximum current that can be applied on the motor is 4 A and the voltage is set at 12 Volts

P = (4) (12)

= 48 W

Now to find the Torque of the motor by using equation 2.2,

$$T = \frac{P}{\omega}$$

The power is obtained from the previous equation and the power is 48 W.

ω is the revolution per minute of the motor which must be converted into rad /s.

ω = 78 rpm = $\frac{2\pi}{60}$ x 78 = 8.168 rad /s

Torque, T= 48/ 8.168

= 5.877 Nm

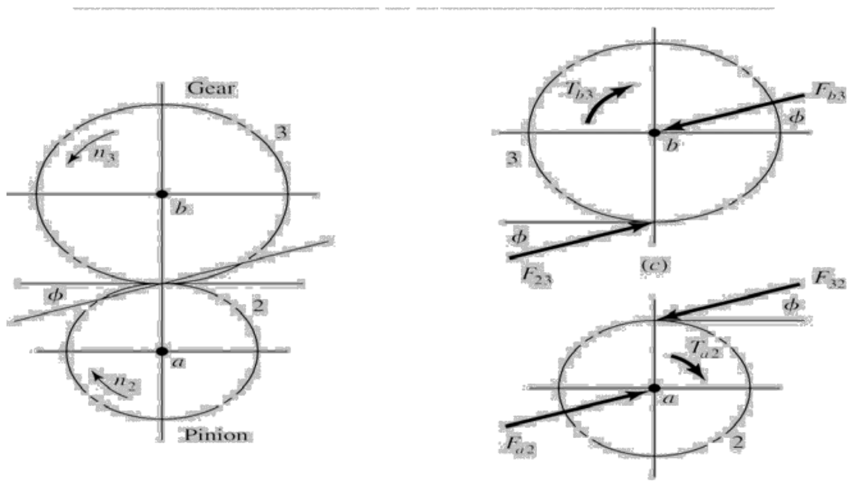


Figure 4.16: Free body diagram shows a pinion mounted on shaft a rotating clockwise at n_2 rev/min and driving a gear on shaft b at n_3 rev/min.

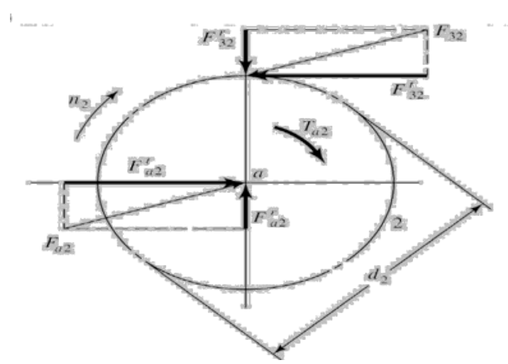


Figure 4.17: The pinion has been separated from the gear and the shaft, and their effects have been replaced by forces

4.7.2 Number of revolution involved in the gearing system:

$$n_3 = \left|\frac{N2}{N3}\, n_2\right| = \left|\frac{d2}{d3}\, n_2\right|$$

n_2= 78 rpm,

$n_3 = \frac{10}{30}$ X 78 = 26 rpm

From equation 2.3, The pinion is on the power window motor which by observation it rotates 78 rpm and then transmitted to the gearing system which then rotated the gear 26 rpm , it reduce 3 times the rotation of pinion.

The free body diagram of the pinion has been redrawn and the forces have been resolved into tangential and radial components.

As the transmitted load, this tangential load is really the useful component, because the radial component F^{r}_{32} serves no useful purpose. It does not transmitted power. The applied torque and the transmitted load are seen to be related by the equation

Denoting by force of the magnitude of the tangential force between gear teeth,

$$\sum M = 0$$

Gear A $\sum M_a = 0$: F^{t}_{32} (0.0127 m) – 5.877 N.m = 0

Gear B $\sum M_b = 0$: F^{t}_{23} (0.0381 m) – 17.631 N.m = 0

F^{t}_{32}= 462.755 N

F^{t}_{23} = 462.755 N

Tangential load,

$$W_t = 2T/d$$

$$W_t = 2\,\frac{(5.877\ N.m)}{0.0254m} = 462.756N$$

From the tangential load also came out with the same result which is 462.756 N. So from the free body diagram analysis and from the tangential equation is also showed the same value so it can be assumed that can proceed with the equation on Lewis equation.

Torque equation,

$T = Fr$

Radius of torque wrench = 0.23m

The maximum torque which obtained from the observation is 9N.m by using the torque wrench.

To find the force that occurs on the torque wrench by human power,

$F = \frac{T}{r}$

F = 9 N.m/ 0.23m = 39.1304 N

The force that occurred on the torque wrench for the maximum torque number of 9N.m is 39.1304N.

From the free body diagram in equilibrium state, the torque that transmitted from the pinion to the gear is 3 times larger which is the value is 17.631N.m.From the observation by using the torque wrench the maximum torque needed to lift the car at height of 29cm is 9N.m.Base on the calculation made, the torque that is produced from the gear is enough to lift the car to a height of 29cm from the ground.

$T_{gear} > T_{observation}$

17.631 N.m > 9N.m

17.631N.m – 9 N.m / (17.631 N.m) x 100% = 48.95 %

Theoretically, the calculation made is correct in order for the gearing system to produced a certain torque to it be able to lift a Kancil’s car. In conclusion, by means of gear ratio 3:1 that has been assumed at the beginning is suitable for the system. Now the fabrication of the gear and pinion can be proceeded. The torque is higher by 48.95 %.

Moreover, from the analysis the actual force needed on the gear can be calculated. The radius of the gear is 0.381m.The maximum torque needed is 9N.m so by using this equation:

$T = Fr$

F= T / r

F = (9N.m) / (0.0381m) = 236.22N

This result is then compared from the free body diagram which came out with a result of the force is 462.55N.Base on these number it can be assumed that the force supplied by the gear on the shaft is more than needed. So by calculation and observation obviously the mechanism will lift the car without a problem.

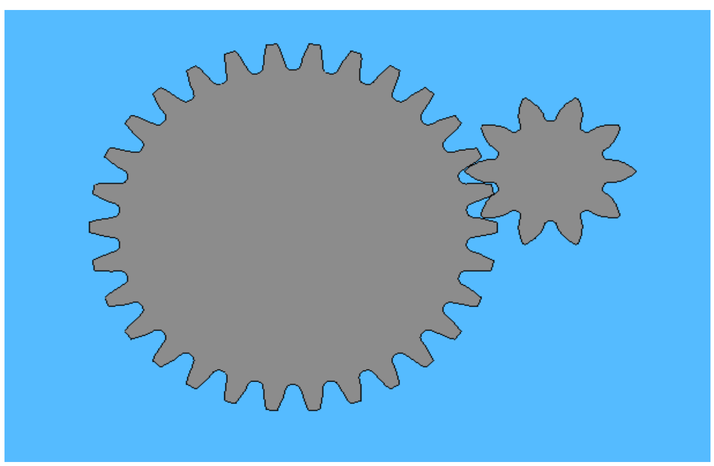


Figure 4.18: The mating between gear and pinion

4.7.3 Stresses on Spur gear Teeth

The two primary failure modes for gears are:

1) Tooth Breakage - from excessive bending stress

2) Surface Pitting/Wear - from excessive contact stress

In both cases, we are interested in the tooth load, which got from the torque, T. Recall that we compute the tangential force on the teeth as Wt = T/r = 2T/D , where D is the pitch diameter.

4.7.3.1 Bending Stress

The classic method of estimating the bending stresses in a gear tooth is the Lewis equation. It models a gear tooth taking the full load at its tip as a simple cantilever beam:

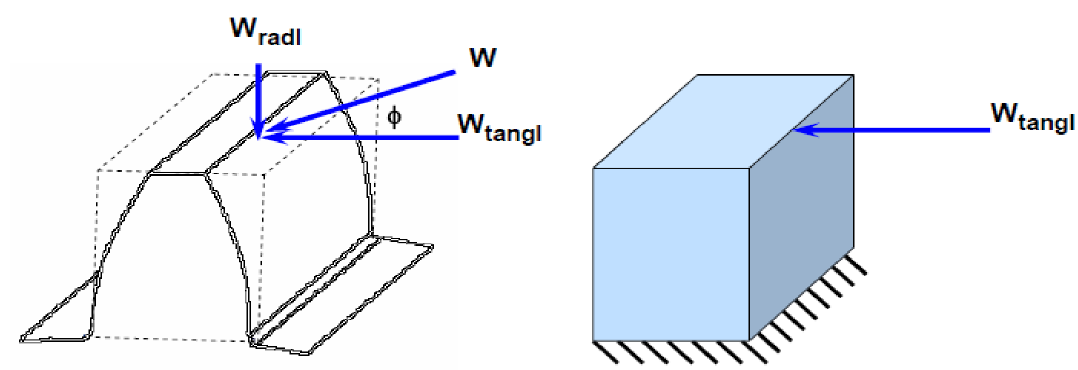


Figure 4.19: Gear teeth and force acting

Lewis bending stress,

From$\sigma = \frac{MC}{I}$, can get the maximum bending stress from equation 2.4 and 2.5,

$$\sigma_t = \frac{W_t P_d}{FY}$$

Or

$$\sigma_t = \frac{W_t}{FYm}$$

Where:

$\mathbf{W_t}$ is the tangential load (lbs),

$\mathbf{P_d}$ is the diametral pitch (in-1),

F is the face width (in), and

Y is the Lewis form factor (dimensionless)

m is the module

The form factor, Y, is a function of the number of teeth, pressure angle, and involute depth of the gear. It accounts for the geometry of the tooth, but does not include stress concentration – that concept was not known in 1892 when Lewis was doing his study.

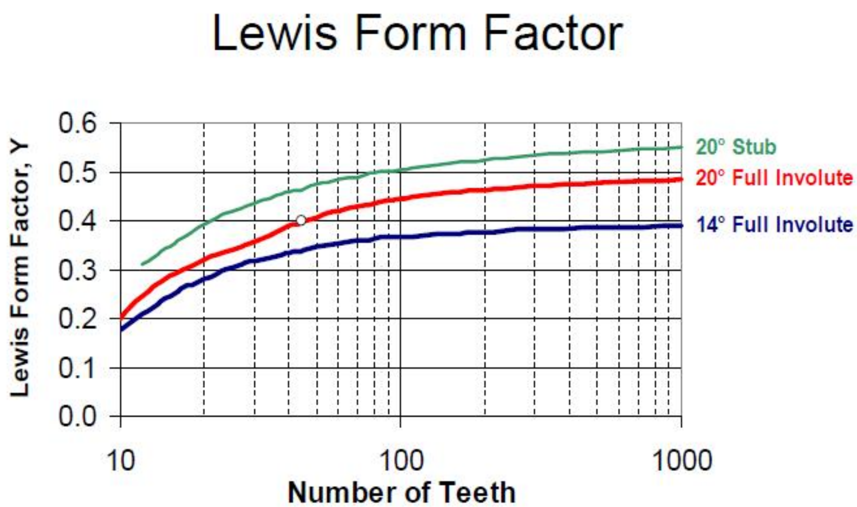


Figure 4.20: Graph of the Lewis form factor base on the number of teeth

Note that since Y is in the denominator, bending stresses are higher for the 14° pressure angle teeth, and for fewer numbers of teeth, i.e. the pinion. Stresses are lower for stub form teeth than for full involutes.

4.7.3.2 Barth Velocity Factor

Since higher velocity gear operation results in increased stresses due to impacts at initial contact, a velocity-based factor is commonly included in tooth bending stress. The Barth velocity factor increases the Lewis stress by approximately:

$$K_v = 1 + \frac{V}{1200}$$

where V is the velocity at the pitch diameter, in feet per minute. The combined expression for tooth bending stress is then:

$$\sigma_t = \frac{W_t P_d}{FY}\ 1 + \frac{V}{1200}$$

Sample Calculation:

W_t=2T/D

W_t = 2 (5.877 N.m) / 0.0254 = 462.756 N

V= 70 rpm x π (1) in/rev x 1ft/12in = 20.42 feet per minute

20.42 x 0.3/60 = 0.1 m/s

V= pitch line velocity

In order to use the Barth Velocity factor, the pitch line velocity must be very high (7.6 m/s).In this gearing system, the velocity is very low, so proceed with the Lewis equation without using the Barth Velocity factor.

Bending stress occurred on the gear tooth,

$$\sigma_t = \frac{W_t}{FYm}$$

σ_t = 462.756 N / (0.012mx 0.2 x 2.54m) = 75.91 kPa

Theoretically, by calculation the stress obtained is 75.91 kPa. Then the stress obtained will be compared with the analyzed gearing system which used ALGOR Finite element analysis. From the analysis will come out with a value which is the material is suitable to fabricate a gear within fit all the specifications needed or not.

4.7.3.3 Allowable Bending Stress

Arriving at a safe allowable stress level for various gear materials is not straight-forward with the Lewis method but then it is only a simplified approximation. Unless it is given a specific material allowable value or a table of values, it is reasonable to estimate an allowable strength as S_{ut} / 3, one third of the material's ultimate tensile strength.

Base on the material that has been selected. The material is a low carbon steel which is A-36.The Ultimate tensile strength, σ = 250MPa.
So the allowable stress for low carbon steel A-36 is 1/3x 400Mpa which is equal to 133.33Mpa.

$$\frac{1}{3} \times 400MPa = 133.33MPa$$

σ_{all} = 133.33Mpa
So the maximum bending stress must not exceed the value of 133.33Mpa.

4.7.3.4 Von Misses Stress

It is used as a criterion in determining the onset of failure in ductile materials. It states that von Mises stress should be less than the yield strength. According to this criterion, also known as the von Mises criterion, after the German-American applied mathematician Richard Von Mises (1883 – 1953), a given structural component is safe as long as the maximum value of the distortion energy per unit volume in that material remains smaller than the distortion energy per unit volume required to cause yield in a tensile-test specimen of the same material.

$$\sigma_{vm} < \sigma_y$$

σ_y for low carbon steel is 250 MPa

So the Von Mises stress value must lower than the σ_y for low carbon steel.

4.7.3.5 FEA analysis on Spur Gears

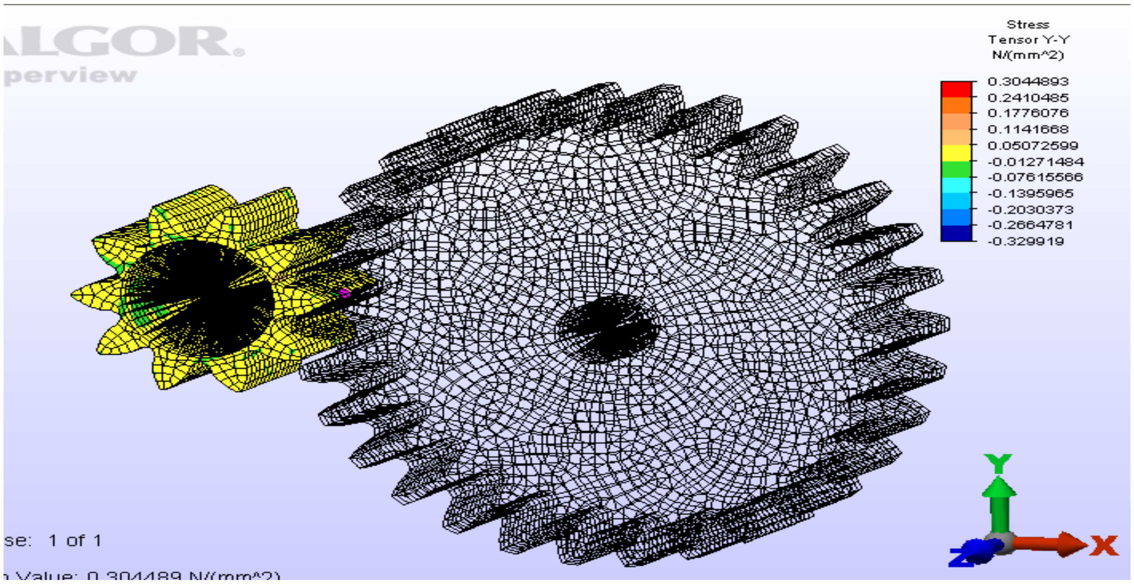


Figure 4.21: Analysis on spur gear

Figure 4.21 shows the analysis on the gearing system which is on a torque value of 5.877N.m .From the result it shows that the maximum stress on the system is 0.3044803 N/mm^2.Base on theoretical value which had been calculated, the allowable bending stress is

σ_{all} = 133.33Mpa.So, it is a safe condition by using this type of materials as a gear. It will not fail in term of mechanically. The material that has been used is A-36 low carbon steel.

The maximum bending stress occurs at the fillet of the gear tooth. This is same condition as a cantilever beam.

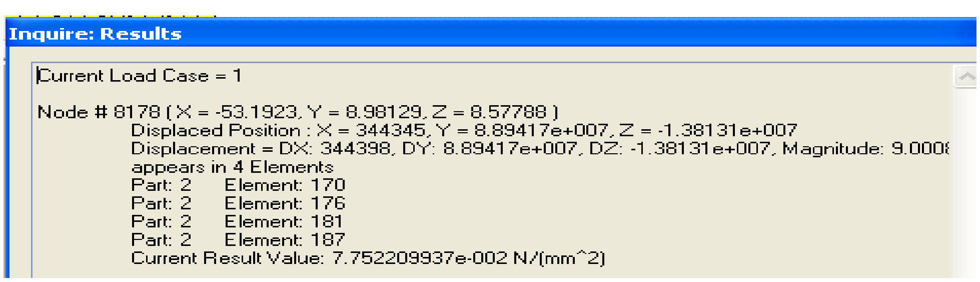


Figure 4.22: Result for point at the tip tooth.

Base on the Figure 4.22, is the results inquire on the tip of the tooth. The result is 77.5 kPa which is from the manual calculation is 75.91kPa.The difference between the two results is:

(77.5kPa – 75.91kPa) / (77.5kPa) x 100% = 2.05 %

Percentage difference = 2.05 %

The difference is due of the limitation of Lewis bending stress equation:

1. Assumes that maximum bending load occurs at the tip. Maximum load occurs near the pitch circle when one tooth carries the entire torque induced load.

2. Considers only bending component of the force acting on the tooth. The radial force will cause a compressive stress over the base cross section.

3. Does not consider contact stresses.

4. Assumes that the loads are static.

Stress Von Mises

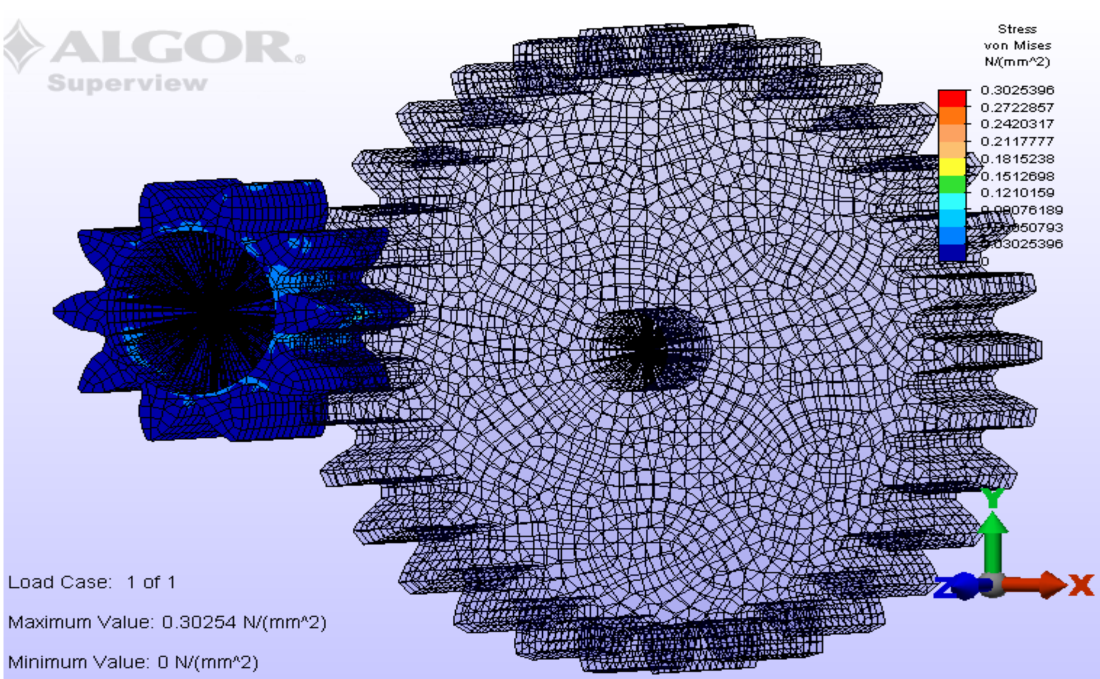


Figure 4.23: Stress Von Mises analysis

From Figure 4.23, it shows that the maximum Von Mises stress value is 0.3026Mpa.From the property of low carbon steel yields strength,

$\sigma_{vm} < \sigma_y$

σ_y for low carbon steel is 250 MPa

So the Von Mises stress value must lower than the σ_y for low carbon steel.

0.3026Mpa < 250 MPa

The gears are safe as long as the maximum value of the distortion energy per unit volume in that material remains smaller than the distortion energy per unit volume required causing yield in a tensile-test specimen of the same material.

4.8 SWITCH CIRCUIT

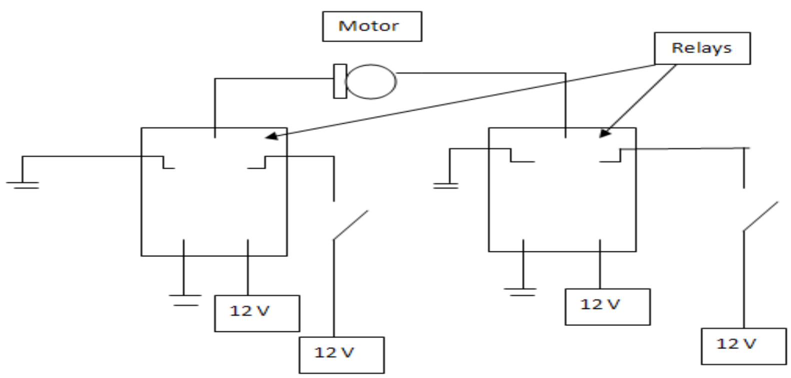


Figure 4.24: Switch circuit

Figure 4.25: Switch button

In this project, switch for the scissor jack to be lifted and lowered are controlled by a switch which have 2 buttons and an on/off switch. This switch circuit is to make the motor enabled to rotate clockwise and counter-clockwise without changing the terminal positive and negative. It is time consumable to change the terminal every time when using this jack, so by using this switch, it is more flexible and easier for the user. The switch also contains 2 relays which will act when a lifting button is press it will actuate one of the relay and it will rotate the motor to the desire level. The most important part is that when the button is release it will stop directly. Let say if the red button is pressed, then it will actuated the coil in relay 1 and then it will change over the switch and supply will flow to the motor and to the second relay which will go directly to negative terminal and the motor will rotate clock-wise. Vice versa, if the black button is pressed.

4.9 SPECIFICATION

Table 4.4: Specifications

Item	Specification
Working	12 V , 4 A
Length (lifting)	480.73mm
Width	386.15mm
Maximum Lifting Height	290mm
Mass	4.6 kg
Operative load (car)	681 kg
Lifting Time	106 seconds

The table 4.4, showed the specification for the developed automatic car jacker. The lifting time is obtained base on average of time when the car is being lifted at a specific height which is 0.29 m. Base on journal wrote by Farhad, the maximum a car can be lifted under a safety condition is 0.32m so in this project only 0.29 m height is used as safety precaution. Moreover, the cable length is 6m which is long enough to be pulled to rear tire from the cigarette car lighter plug in. The mass is measure using weight machine which the total mass of 4.6Kg.All the working requirements are base on the motor specifications.

4.9.1 Cost Analysis

Table 4.5: Cost Analysis

Parts	Quantity	Cost (RM)
Scissor jack	1	Donated
12V car cigarette lighter adaptor	1	Donated
Motor	1	180.00
Miscellaneous	-	20.00
Switch	1	10.00
Lab equipment	-	Donated
Cable & screws	-	Donated
GRAND TOTAL	**N/A**	**RM210**

From table 4.5, it shows the cost analysis for the project. Base on this project, the grand total required is RM 210 which is most of the cost if from the motor. The motor that has been used in this project is Bosch Volvo 240 which recommended by the co-supervisor. The motor is reliable and able to give the output torque needed for the project. This project is done in the FKM lab which the cost of the lab is considered miscellaneous. Moreover, the equipments for the switch are supplied from Kuala Lumpur. Although all the equipments for the switch are small, the cost is very high because of the electronics part.

CHAPTER 5

CONCLUSION AND RECOMMENDATIONS

5.1 INTRODUCTION

Chapter 5 is the last chapter in this thesis writing. In this chapter, the whole conclusion of this project that has been carried out in the last two semesters will be disclosed.

5.2 ACCOMPLISHMENT

In general, the accomplishment of this automatic car jack powered by internal car power can be divided into two parts. The part one consists of introduction, literature review and methodology. In part two, consist of results and discussion and conclusion and recommendations. In the part two, fabrication, analysis and testing process involved where have been carried out through the semester 7 of studies.

5.2.1 Accomplishment of Part 1

In first part, the tasks are divided into several steps as shown in figure 5.1.

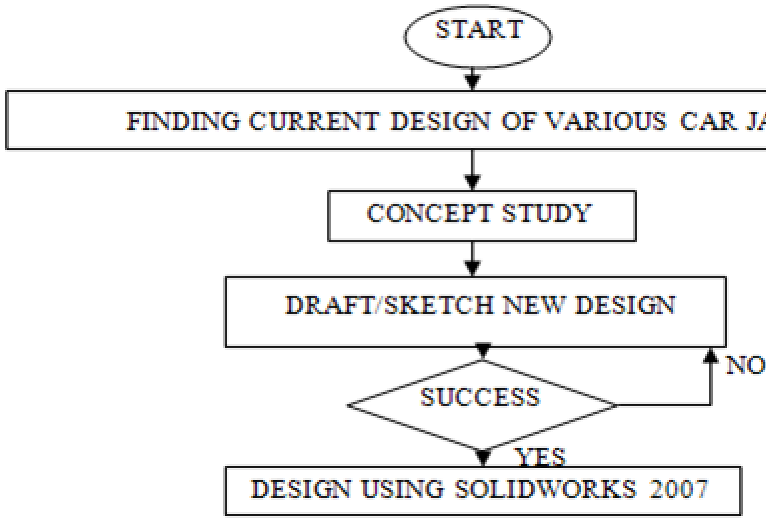


Figure 5.1: Final Year project 1

In first level, research on current car jacks has been done. All the information about the objectives, scopes and problem statements has been discussed in chapter 1.In the chapter 1, the thesis is about introduction about car jacks to the reader and about the accomplishment of the whole project concluded into the gantt chart. The objectives of chapter 1 are to give a general overview of the project to the reader.

In the second level, the writings are about literature review that has been carried out. The main purpose of this literature review is to get information about the project from the reference books, magazines, journals, technical papers and web sites, where it helps me to generate ideas on a proper design on the current design of a car jack. In this chapter, all the information that has been gathered discussed briefly. One of them was about the current problems faced by the people who used a car jack in term of usage, ergonomic, stability and failure of mechanical component such as oil leakage on a hydraulic jack.

In the third level, discussion about the design consideration, components and materials have done. After all the studies, the conceptual design of automatic car jacker sketched and modeled using Solidworks program .The design, components and function are gathered after a details discussion with the supervisors. The ideas are gathered and put in one place so that in can be brainstormed and be able to come out with a proper and function automatic car jack.

5.2.2 Accomplishment of part 2

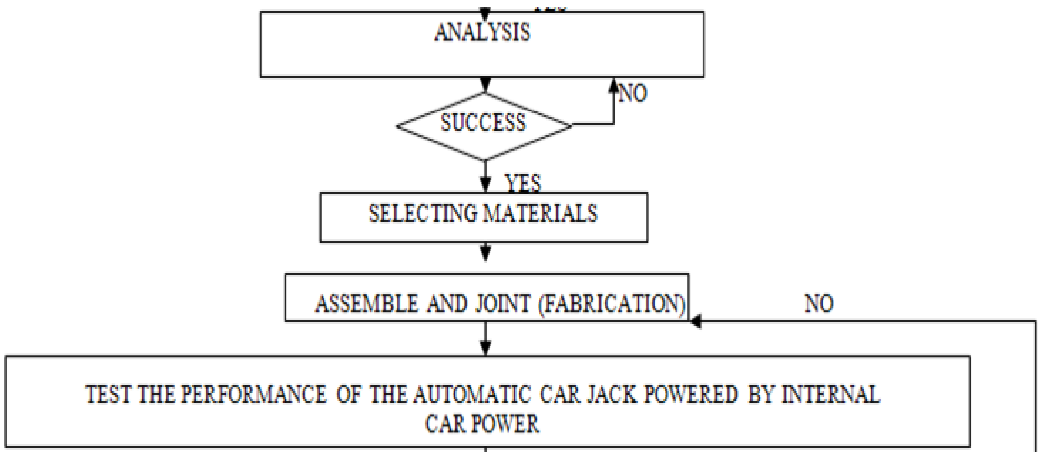


Figure 5.2: Final Year Project 2

The second part of the project started with modeling again with detail drawing after a certain confirmation and consultation from friends and supervisors. After the detail modeling is done, the designed solid parts are used to identify the analysis on the gearing system where all the observations for the projects are done; the suitable components to make sure it is working properly followed the right specifications. The calculations for the gearing system are compared with the value from the observation which the torque is taken under consideration as torque is the main important factor.

After all the basic components are chosen, the fabrication process is started. The fabrication process consists of welding, bending, machining using Wire cutting EDM, shearing, drilling, grinding and spraying. All the parts manufactured as in the design and all the torque followed as in final drawing .After all the parts finish manufactured, the parts assembled according the drawing and ideas, then the electrical parts are made. The electrical parts are the motor and switch for the motor to work clockwise and counter clockwise. The switch then is installed in a proper black box which is easier to hold with both hands.

In conclusion, this project is a success and met all the objectives and scopes that have been set which is able to design a safe and reliable car jack which can be operated in lifting and lowering the car. Moreover it also able to develop a car jack which can be automated using switch button system. This project is continuous from the Final Year Project 1 which followed all the methodology. The steps are base on the methodology and gantt chart. This project also taught on how to use different kind of machines in the lab such as Wire EDM cutting machine, MIG (Metal Inert Gas), Bend saw and Bending Machine. Moreover it also involves a lot of dealing with people from outsider, friends, lecturers and instructor. It is based on a long learning process which has been in the FKM objective. Furthermore, FYP 1 and FYP 2 taught on report preparation and presentation of the project.

5.3 RECOMMENDATIONS

The fabricated automatic car jacker has many weaknesses that can be improved in the future. Some of the weaknesses are to be discussed here:

5.3.1 Weight

Weight or mass of this automatic car jacker is 4.4 kg which is larger than normal scissor jack. But for the overall stability the weight is from the L iron bar. The weight maybe can be reduced by using a more convenient design for the stability system or find a proper motor which is the shaft is in-line with the scissor jack shaft. If the motor is in-line with the scissor jack system, the stability can be increased by using only using a small piece of L iron bar on the side of the motor placement.

5.3.2 Motor

Base on the observation, the motor is not that fast enough to lift jack and the car. In term of motor, higher torque motor will give an advantage for this lifting mechanism. A proper motor have been found. The calculation has been made between the motor and the gearing. So, theoretically it will work fine. The motor that is suggested is Baldor Power window which is the cost is $399.The motor has specification of 120W,130 revolution per minute and maximum current is 10A.But in this case of motor, a fuse needed to avoid any circuit short in the switch system.

Figure 5.3: Baldor power window motor (419875 CE/ROHS)

5.3.3 Gearing

The gearing parts used mild steels as the material. The gears also increased the weight of the system which the weight can be reduced by using a lighter material such as Nylon 6/6.The Nylon 6/6 has almost the same material properties as low carbon steel such as the yield strength. Moreover the density of nylon 6/6 is much lighter than low carbon steel. The density for nylon 6/6 density is 1010kg/m^3 and for low carbon steel is 7850 kg/m^3 which are lighter 87% than low carbon steel.

The gearing system is not so smooth. So, to encounter the problem, the gears mates have been wipe with grease to make the mating smoother. The grease is water resistant grease which can pro-long the wear resistant since it is also anti rust grease. Furthermore, the shaft distances maybe another problem. A proper distance of the shaft can make the gearing system rotate smoother.

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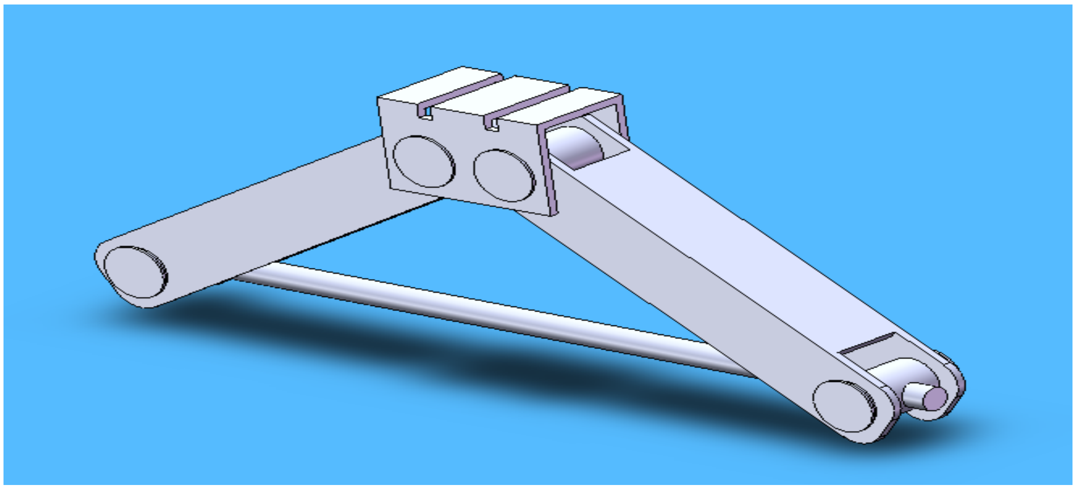
15. William H. Crouse and Donald L. Anglin, *Automotive Mechanics* 10th edition, 1993.

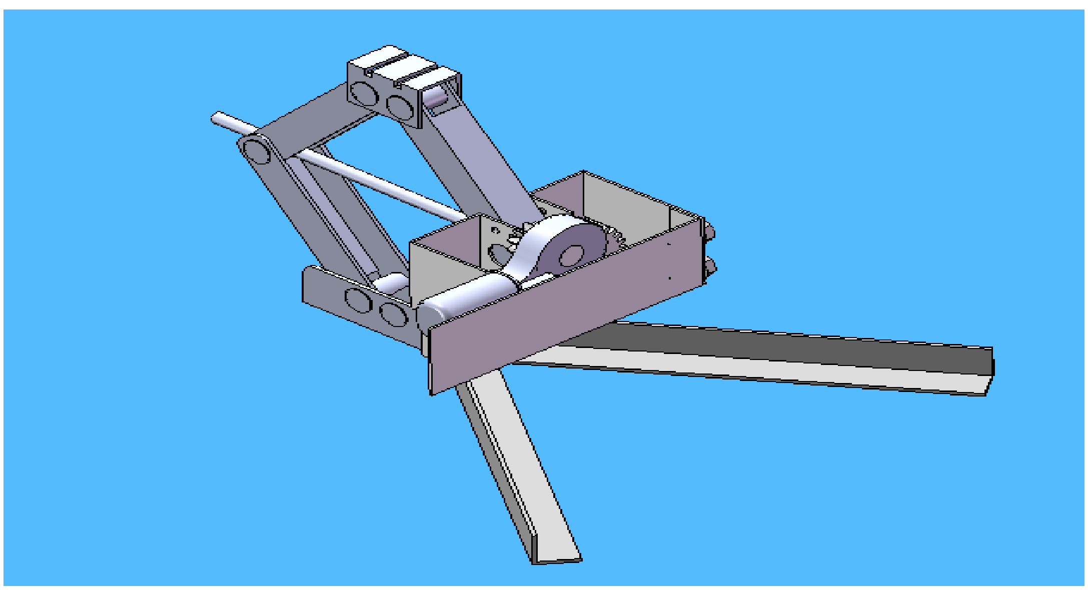
16. Yang –chou Liu, Taipei, Taiwan. ‘Manually operated car jack’ United States Patent. Patent number: 5603486.Date of Patent: Feb 18, 1997.

APPENDIX A

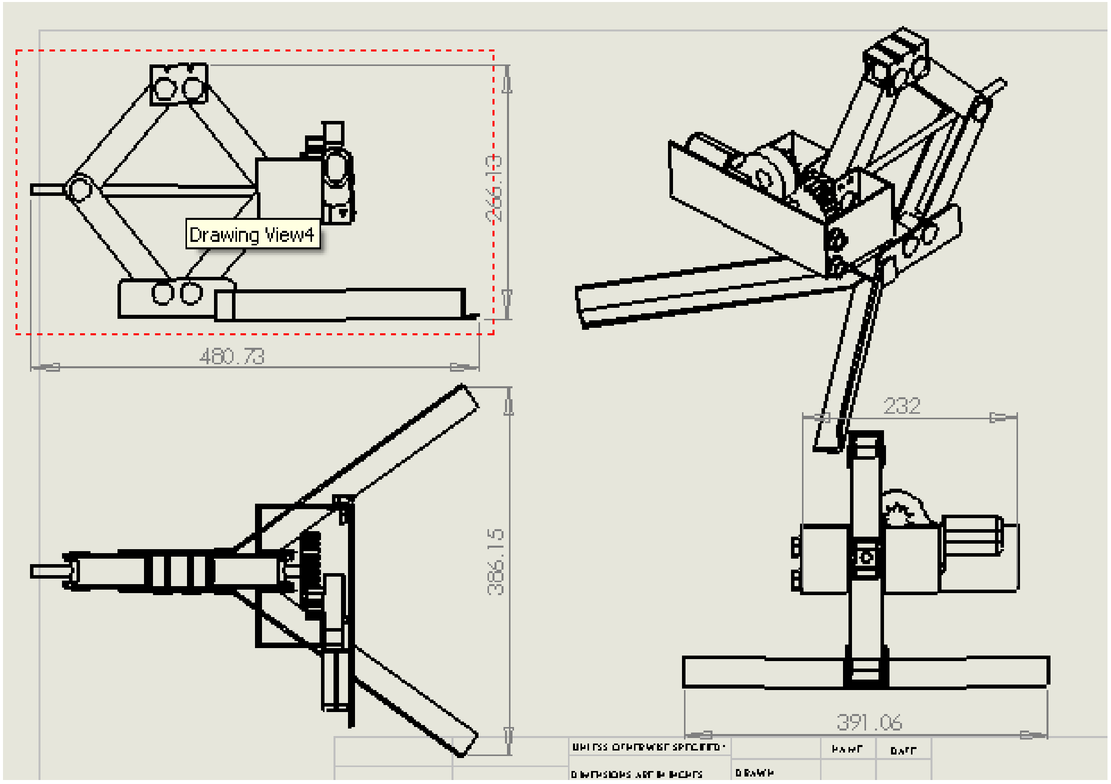
ENGINEERING DRAWINGS



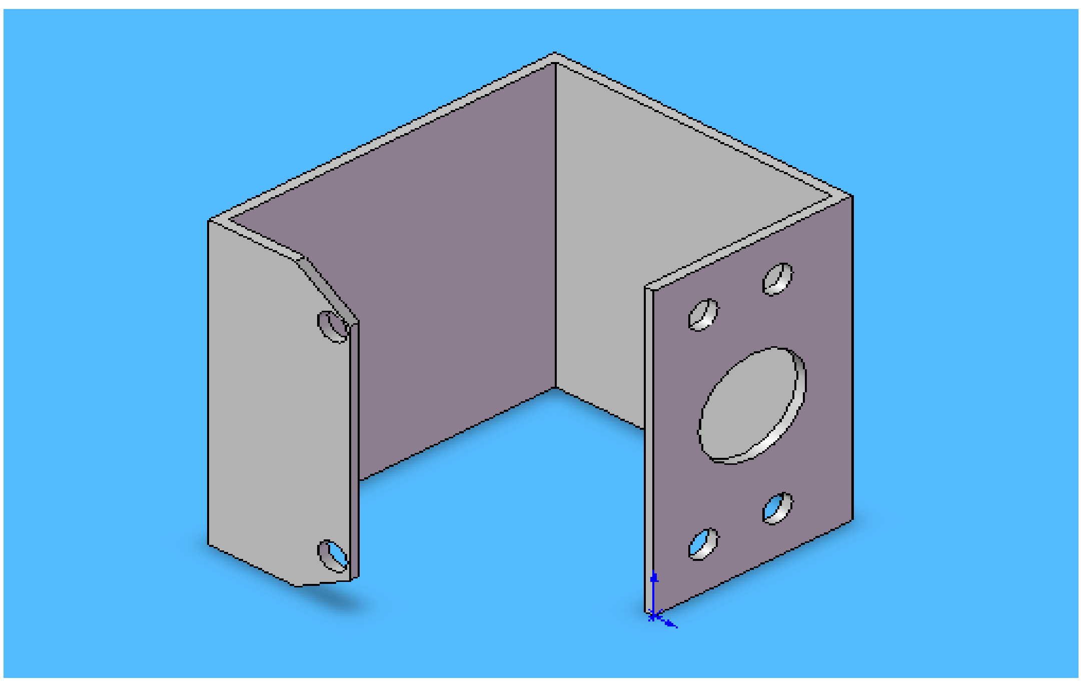
Isometric view of upper part of scissor jack



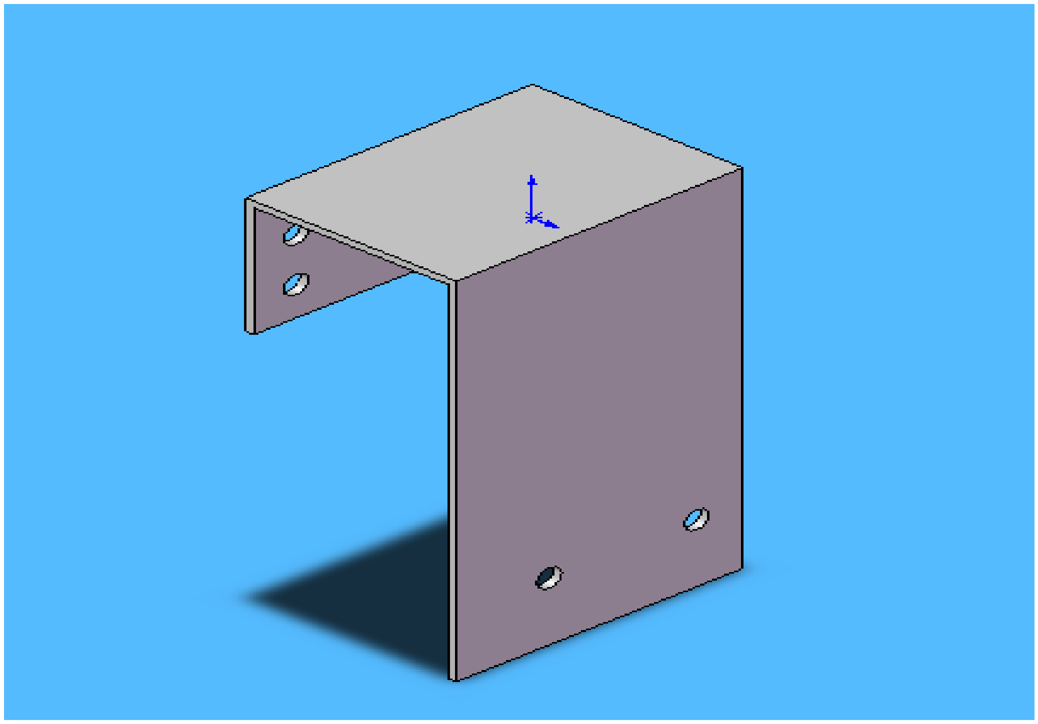
Isometric view of prototype automatic car jacker



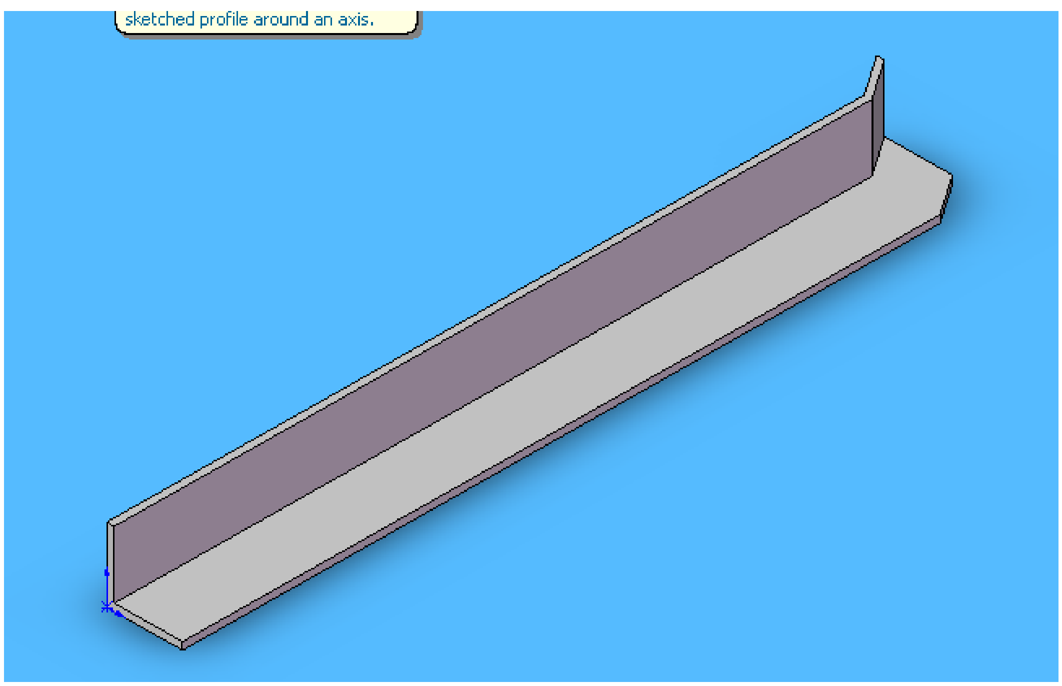
Full dimensions of prototype automatic car jacker



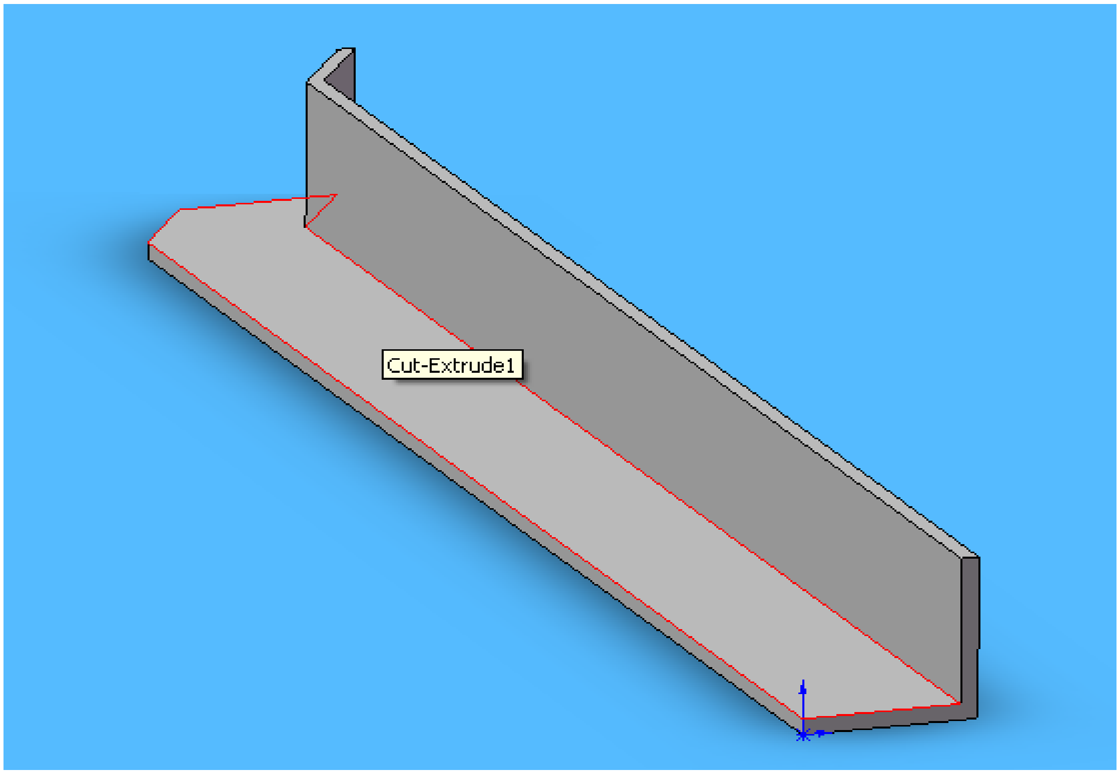
Frame holder for left side



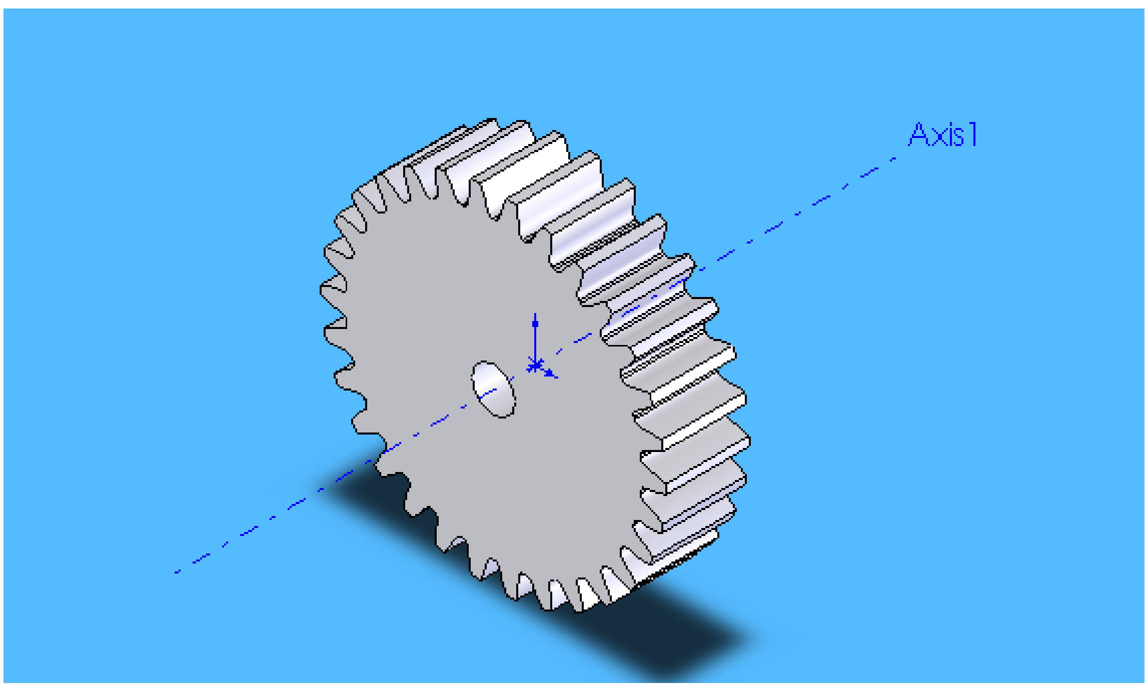
Frame holder for right side



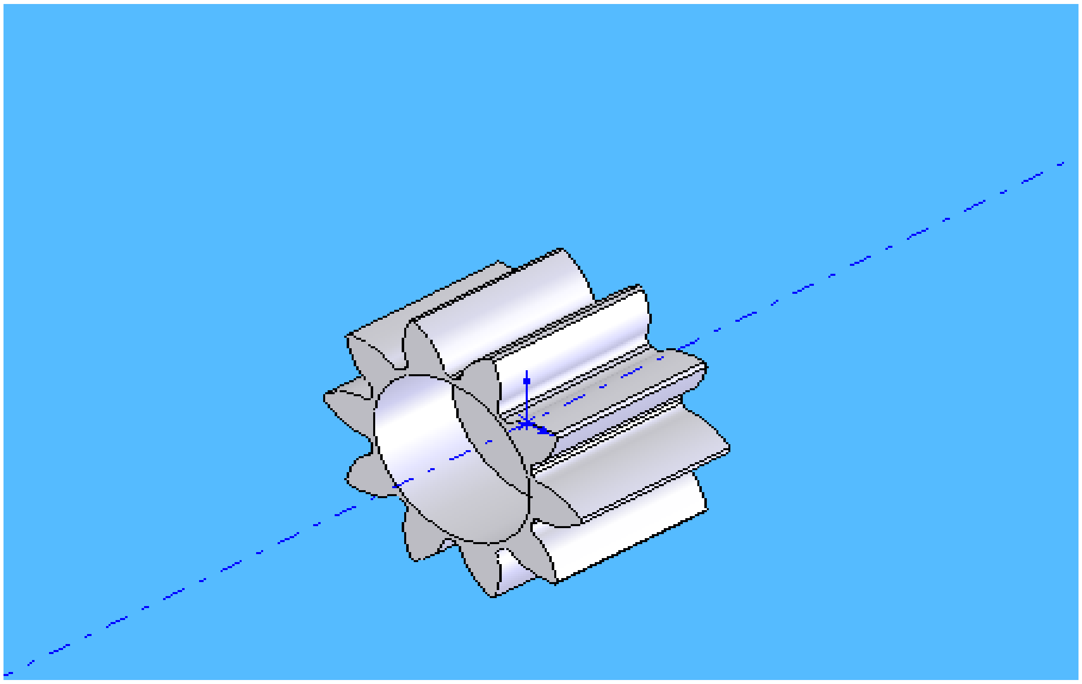
Stabilizer bar for left side



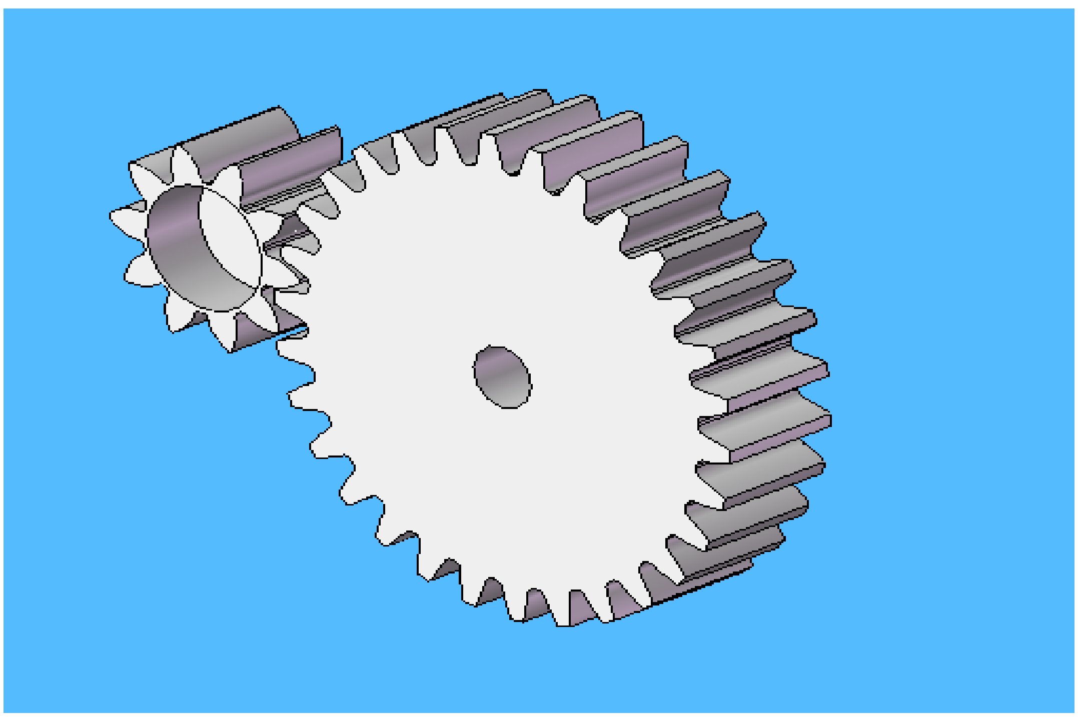
Stabilizer bar for right side



Design for gear with 30 teeth



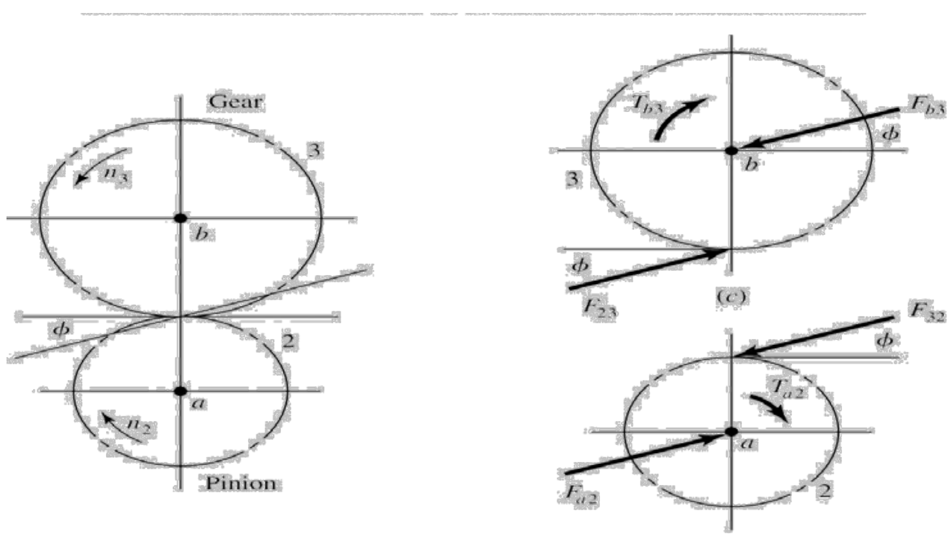
Design for pinion with 10 teeth



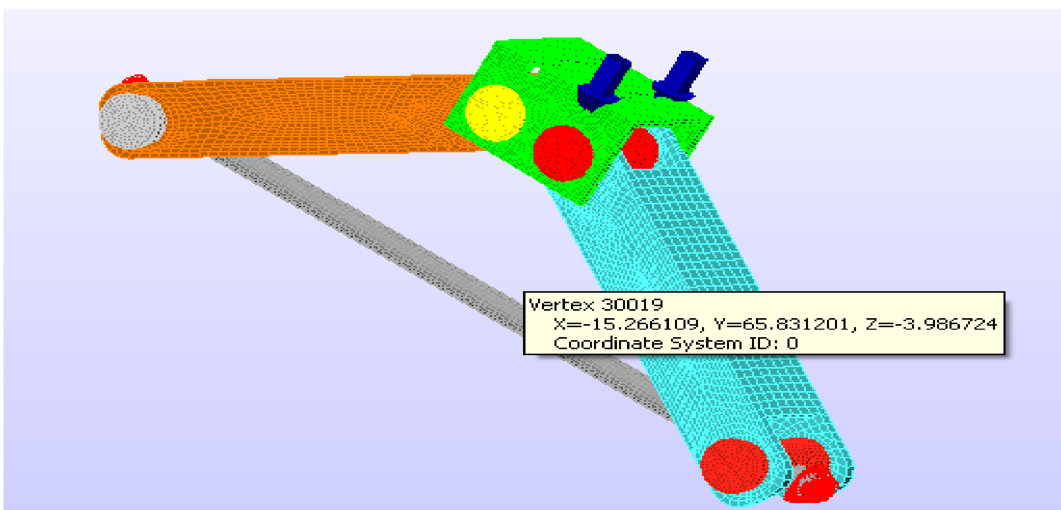
Gear and pinion transmission

APPENDIX B

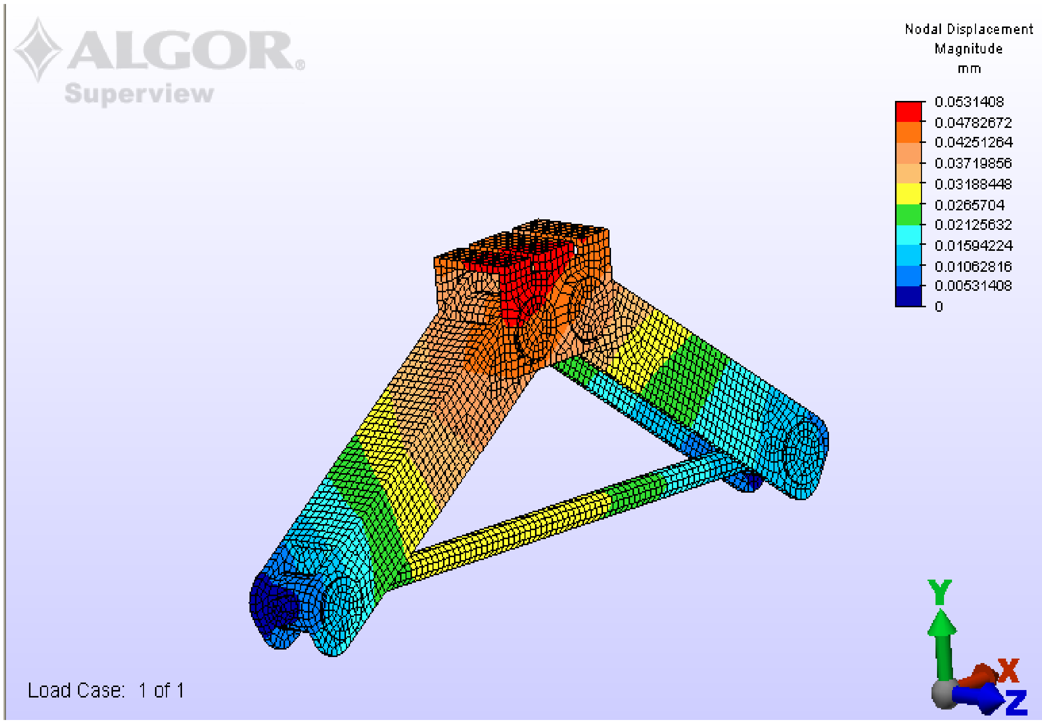
FIGURES OF PROTOTYPE ANALYSIS



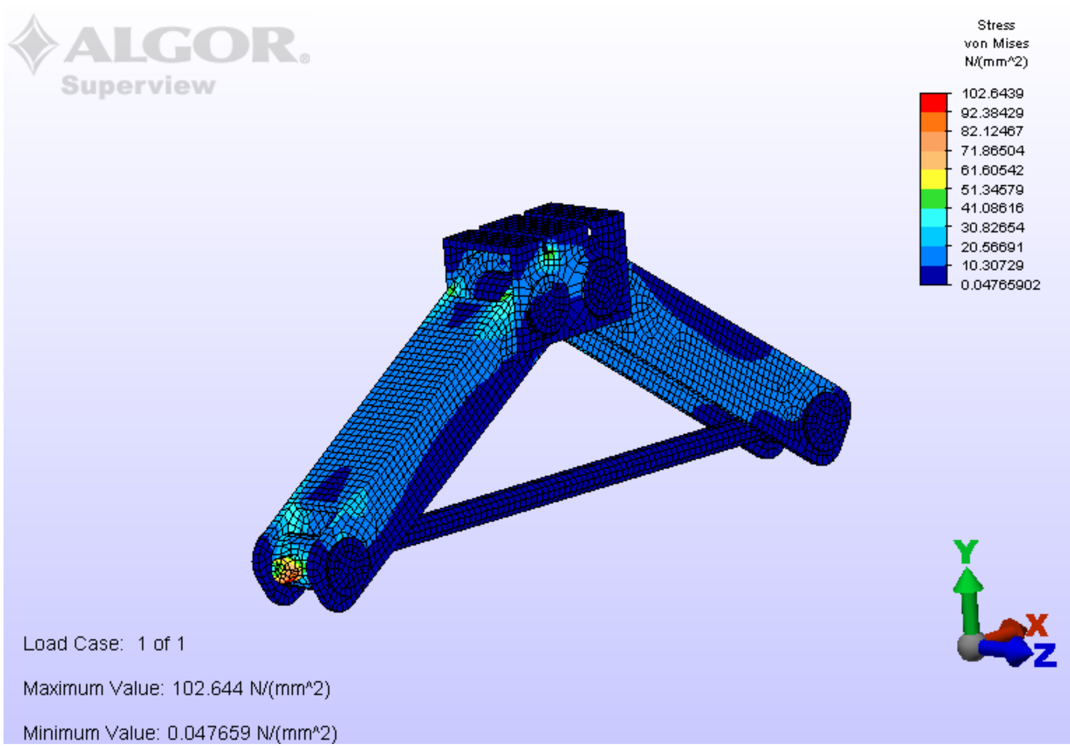
Shows a pinion mounted on shaft a rotating clockwise at n_2 rev/min and driving a gear on shaft b at n_3 rev/min



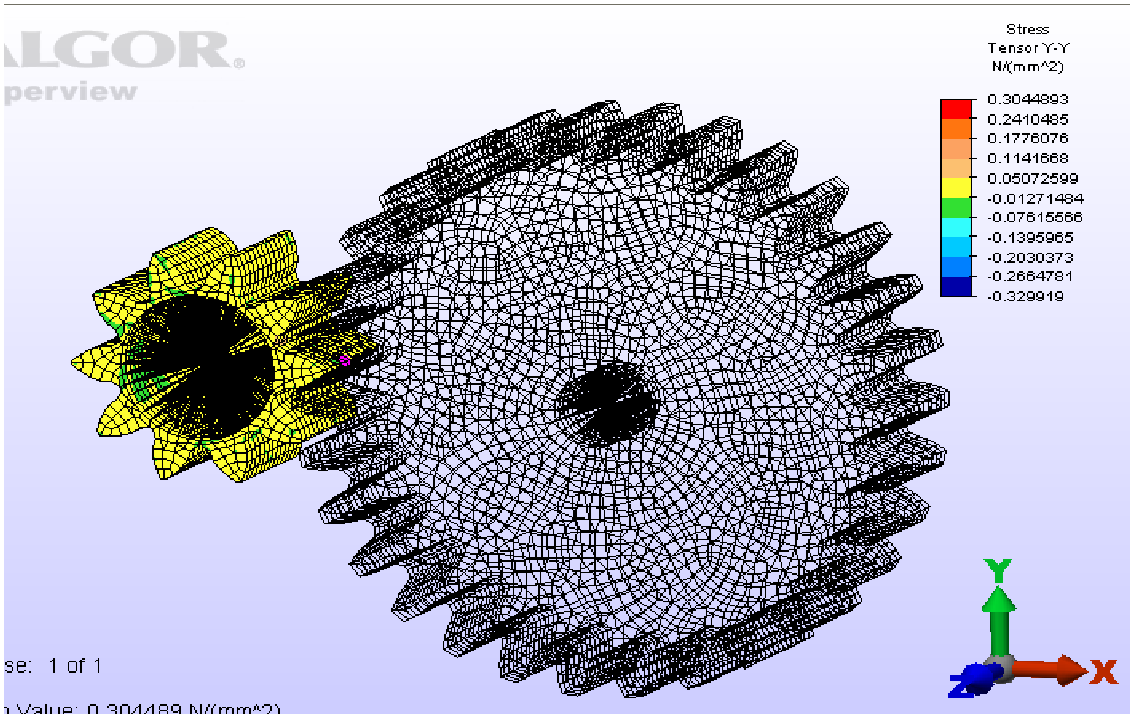
Shows the fixed point and the load applied on the system analysis



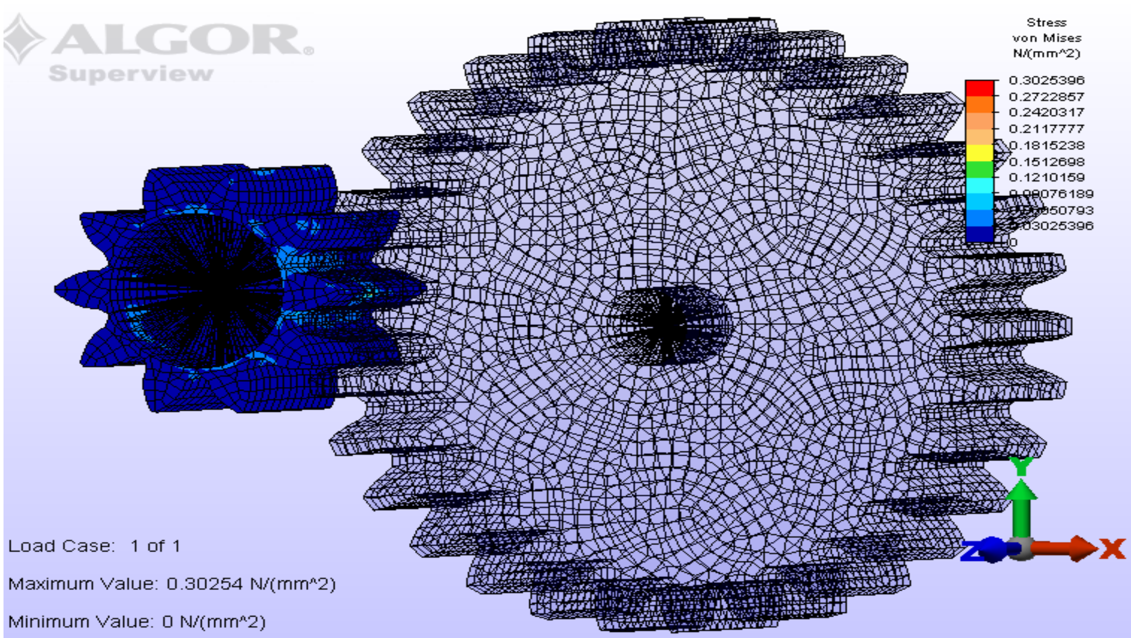
Maximum value for sample 2943.0 N load



Maximum value for load 300kg for nodal displacement and stress Von Misses



Analysis on spur gear



Stress Von Mises analysis

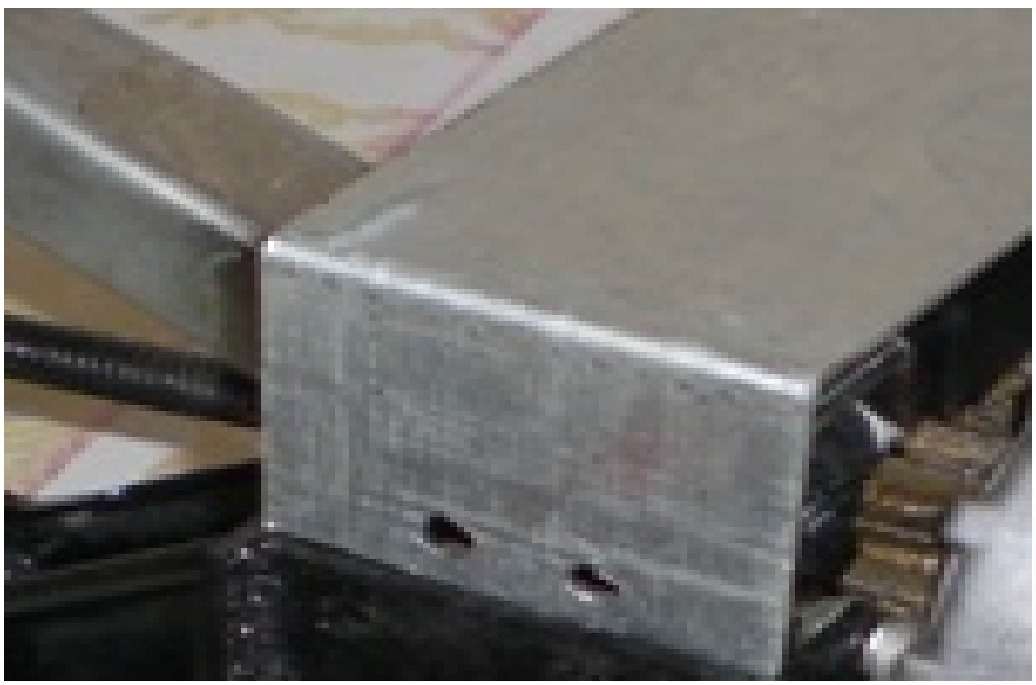
APPENDIX C

FIGURES OF THE PROTOTYPE AND FABRICATION PROCESS

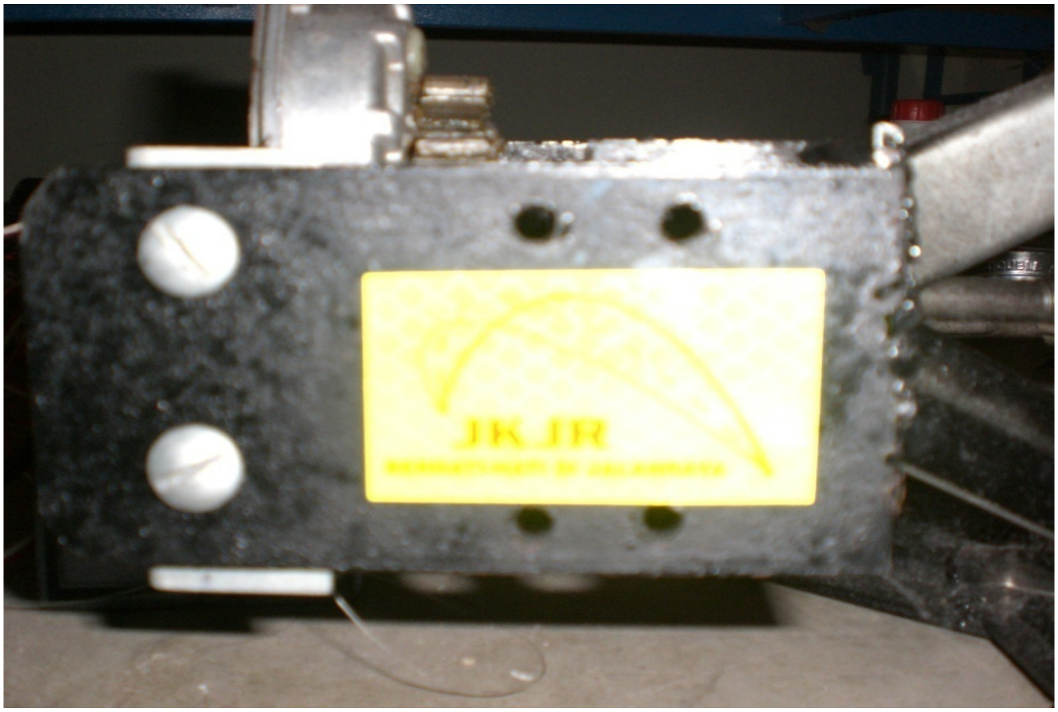
Programming the gears design into wire EDM machine

The fabricated gear and the frame

Using bending machine to bend the cover for the gearing system



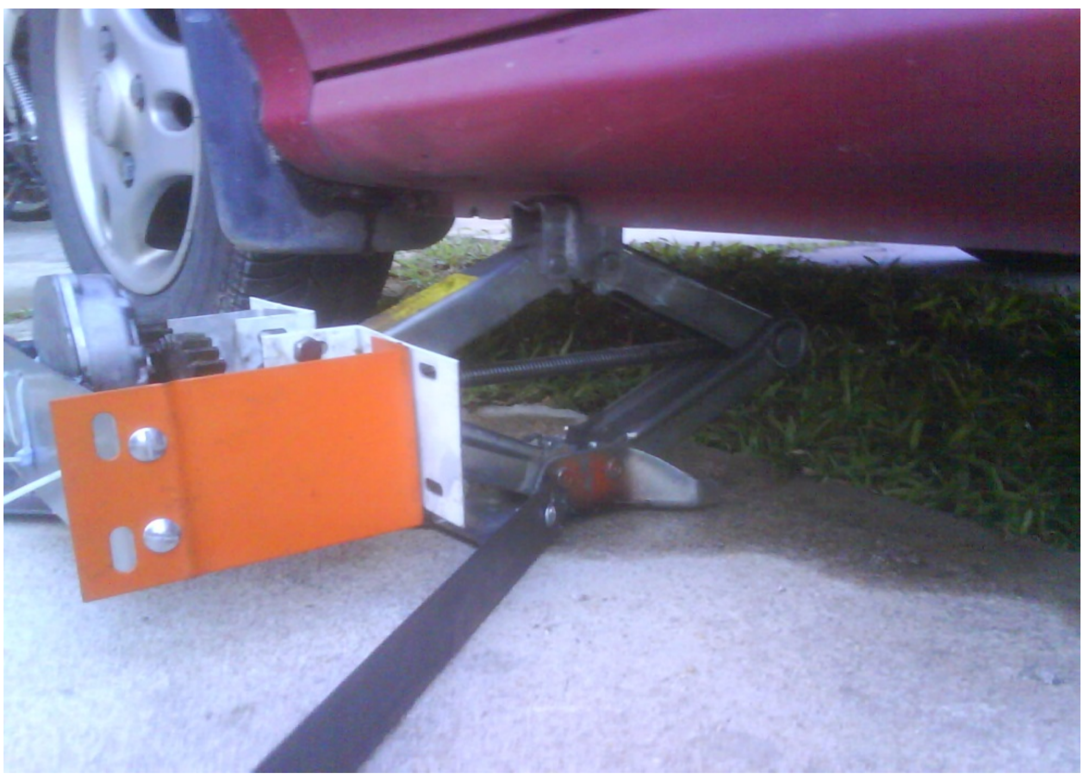
The cover for gearing system



Side view for the frame holder

The fabricated pinion on the shaft of the motor

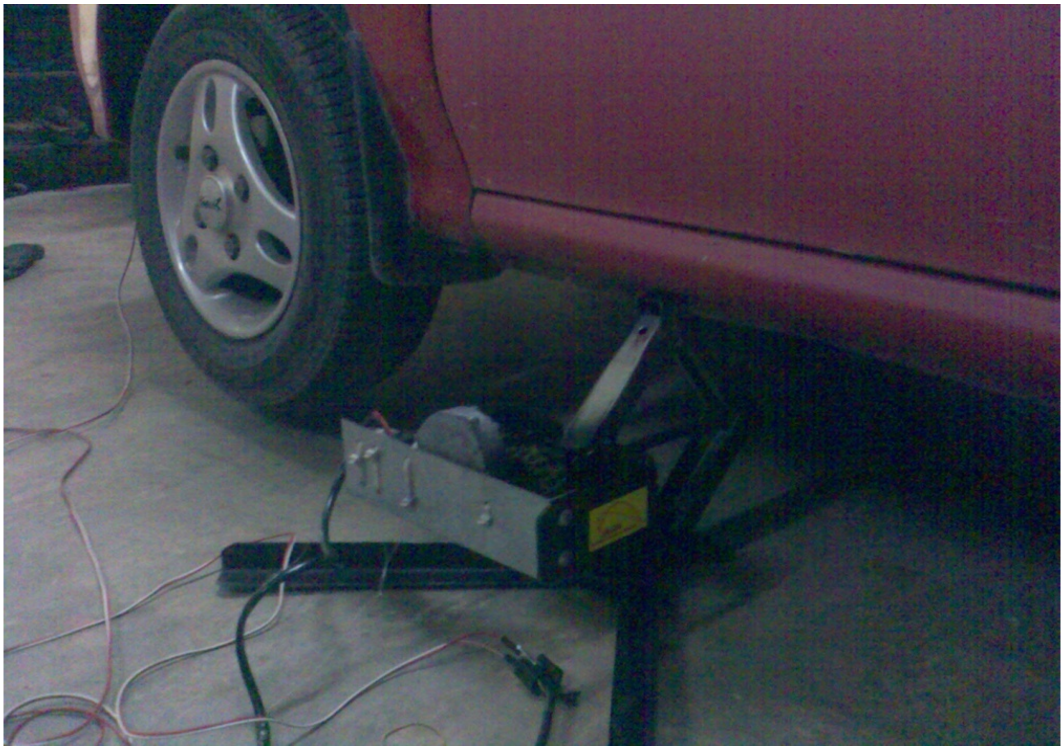
Using torque wrench to observed the torque needed



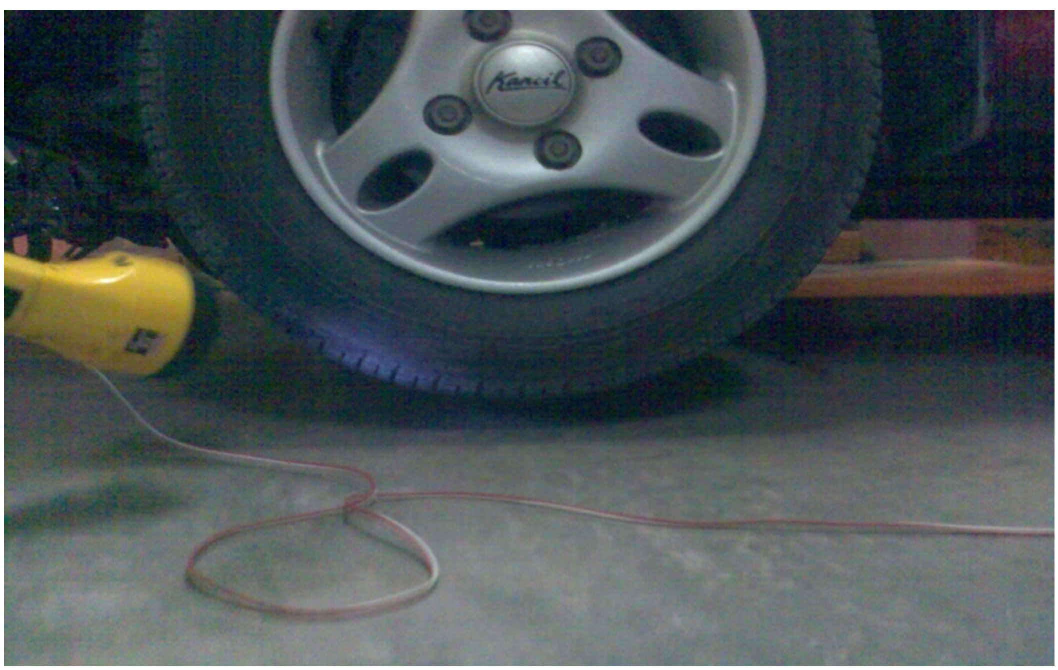
First test on the prototype automatic car jacker

Front view of the car after the first test

Side view



Final test after re-fabricated the frame holder



The lifting of the front tire

The developed automatic car jacker