**APPROVAL**

"I hereby declare that I have read this thesis and in my opinion this thesis is sufficient in term of scope and quality for the award of Bachelor of Mechanical Engineering (Design & innovation)"

Signature : ……
Supervisor's Name : En Mohd Nazim Bin Abd Rahman
Date : 22 April 2011

**DECLARATION**

"I hereby, declare this thesis is result of my own research except as cited in the references"

Signature : ……
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# ABSTRACT

Car jack is a device used to lift up the cars while changing the tires during an emergency. Car jacks are available at the market has some disadvantages such as requiring more energy to operate, are not suitable for women and cannot be used on the uneven surface. The purpose of this project is to modify the design of the existing car jack in terms of its functionality and also human factors considerations. In this "Projek Sarjana Muda 1", the scopes of research were on the designing 1.5 - 3 ton maximum lifting capacity of car jack by using optimization concept. To optimize the existing design, the hand lifter has been replaced by the use of pedal lever as it can reduce energy usage. In addition, ergonomic factors are also taken into consideration in order to reduce and simplify how to use a car jack. In the process of obtaining a suitable design, the customer needs will be translate to the engineering characteristic to obtain the concepts that need to be modified and fabricated. From the house of quality, the best concept will be valued based on the weighted rating method. The morphology chart had been used to obtain the best concept solution. After the best concept had been selected using the weighted rating method, next step was to determine the part and component that can be modified by arrange the part into chunks and clustering with the component according to the function or system. From this step, it can be determined which component can be reduced or modified. Then the configuration design was analyzed according the function factor and critical issue so that the design that had been implementing was according to the specification and customer requirement. The last step for this project was parametric design. In this topic, the new design concept will be calculated to obtain the required force and compared with the theoretical calculation in the table of human factor.

# ABSTRAK

Jek kereta merupakan satu alat yang digunakan untuk mengangkat kereta semasa ingin menukar tayar di waktu kecemasan. Jek kereta yang sedia ada di pasaran mempunyai beberapa kelemahan seperti memerlukan banyak tenaga untuk beroperasi, tidak sesuai untuk wanita dan juga tidak boleh di gunakan di atas permukaan yg tidak rata. Tujuan tajuk ini adalah untuk mengubah suai rekabentuk jek kereta yang sedia ada di dalam fungsinya dan juga dari segi pertimbangan faktor manusia. Di dalam Projek Sarjana Muda 1, kajian yang dilakukan adalah untuk mengkaji setiap komponen jek kereta dan pengubahsuaian yang boleh dilakukan oleh jek kereta kapasiti 3 tan maksimum. Untuk mengoptimumkan rekabentuk sedia ada, penggunaan pemijak kaki telah digantikan bagi mengantikan tuil tangan disamping itu dapat mengurangkan tenaga yang digunakan. Selain itu, faktor ergonomik juga di ambil kira supaya dapat mengurangkan serta memudahkan cara untuk menggunakan jek kereta. Di dalam proses untuk mendapatkan rekabentuk yang sesuai, proses yang di ambil kira adalah daripada kehendak pelanggan dan kemudiannya diterjemahakan kepada ciri-ciri kejuruteraan untuk mendapatkan idea dan konsep yang perlu diubahsuai di dalam rumah kualiti. Setelah itu jadual morfologi dibagunkan untuk memperolehi konsep pengubahsuaian yang baru. Konsep terbaik telah dipilih dengan menggunakan kaedah penentu tertimbang. Manakala langkah seterusnya adalah untuk menentukan bahagian-bahagian yang boleh diubahsuai adalah dengan menetapkan bahagian menjadi potongan-potongan dan kluster dengan komponen sesuai dengan fungsi atau sistem. Dari langkah ini, dapat ditentukan dengan komponen dapat dikurangkan atau diubahsuai. Kemudian rekabentuk tersebut dianalisis mengikut fungsi dan isu-isu kritikal sehingga rekabentuk yang telah diubahsuai itu sesuai dengan spesifikasi dan keperluan pelanggan. Langkah terakhir untuk projek ini adalah analisis rekabentuk parametrik. Dalam topik ini, konsep rekabentuk baru akan dinilai dari segi daya yang diperlukan dan akan dibandingkan dengan nilai teori dalam jadual.

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## LIST OF SYMBOL / ABBREVIATION

| | | |
|---|---|---|
| F | = | Force (N) |
| $F_m$ | = | Force produce by men (N) |
| $F_w$ | = | Force produce by women (N) |
| $W_m$ | = | Weight average for men (kg) |
| $W_w$ | = | Weight average for women (kg) |
| A | = | Area ($m^2$) |
| m | = | Mass (kg) |
| P | = | Pressure ($N/m^2$) |
| D | = | Diameter |

# CHAPTER 1

# INTRODUCTION

## 1.1 Car Jack

A jack is mechanical device used to lift heavy loads or apply great forces. Jacks employ a screw thread or hydraulic cylinder to apply very high linear forces. A mechanical jack is a device which lifts heavy equipment. Car jacks usually use mechanical advantage to allow a human to lift a vehicle by manual force alone. More powerful jacks use hydraulic power to provide more lift over greater distance. The mechanical advantage is the factor by which a mechanism multiplies the force or torque applied to it.

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 auto jack that was still included as standard equipment with most new cars. These days, fewer people than ever have had to use a car jack. This is due to the continuing improvements in modern tires that have made "getting a flat" rare. 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. *(http://cotsncots.com/faq-general.html).*

## 1.2 Problem Statement

Nowadays in this country, most of the cars were equipped with the scissor car jack. We found that the scissor car jack were very difficult to be used especially by women because this types of jack needed more strength and energy to operate this jack by turning the lead screw. Thus, we want to develop a product based from the problem faced by the users who drive a car regarding to this issue. To overcome this problem, a research has been conducted to find the solution on how to design a car jack for the car using the simplest and cheapest way while it is energy saving. Although there were many ways to solve this problem, we recommend that the design this car jack system is the practical way when we considered all the factors and consequences especially about the analysis to develop this product. During the research, we have found that most of the car user has difficulties in maintaining their vehicles breakdown especially cars in the scope of changing tires. The normal car jack we have in the market is operated using bare hands and it is time consuming. It also requires much energy from the person to rotate the jack. Hence, this report had been prepared to recommend the design of the car jack that is user friendly and easier to operate as do not required too much money to develop this product.

## 1.3 Objective

Design improvement the existing car jack in terms of its functionality and human factor consideration.

## 1.4 PSM Flow Chart

Flow charts are a modelling technique introduced in the 1940/50s and popularized for structured development in the 1970s *(Gane and Sarson 1979)*

as well as project planning. Figure 1 depicts a flow chart for the project (PSM) from the beginning until the end of the project. There are two basic symbols on this flow chart, squares which represent activities or tasks and arrows which represent flow of control.

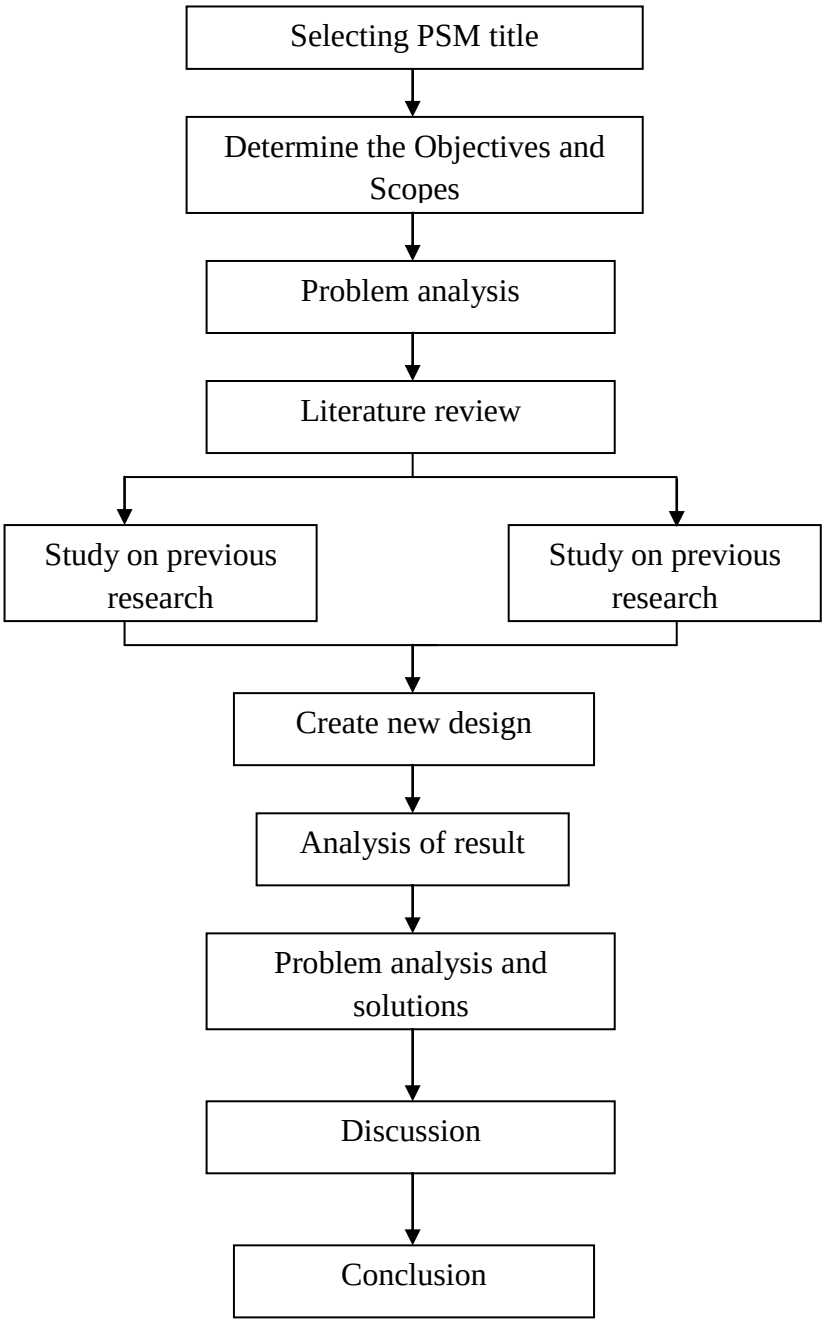


**Figure 1** PSM Flow Chart

## 1.5 Scopes

This project is about the designing and fabricating the car jack. The types of car jack that we were used in this project were hydraulic car jack as it is more reliable and easy to operate. In order to develop new concept of the car jack design, we do some research on by giving questionnaire to car user. The scopes of research were on the designing 3 ton maximum lifting capacity of car jack by using optimization concept.

For optimizing the human power, the concepts that will be used in this product were replacing the long arm with the leg pad. By this, the mechanical advantage while lifting can be reducing. In our design we were using CAD to draw out the detailed drawing of each component of our product.

Therefore, the deformation, von stress misses, and the factor of safety of pedal lever will be analyzed using the Finite Element Analysis Software. From our analysis, we will propose the best concept of the car jack in terms of friendly user and lower cost in product development.

# CHAPTER 2

# LITERATURE STUDY

## 2.1 Existing Car Jack

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 by manual force alone. 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). The jack shown in figure 2 is made for a modern vehicle and the notch fits into a hard point on a body. Earlier versions have a platform to lift on the vehicle frame or axle. *(http://en.wikipedia. org/wiki/Jack_ (device))*

**Figure 2** Garage Car Jack
(Photo by www.NorthenTool.com)

A hydraulic jack uses a fluid, which is incompressible, that is forced into a cylinder by a pump plunger. Oil is used since it is self lubricating and

stable. When the plunger pulls back, it draws oil out of the reservoir through a suction check valve into pump chamber. When the plunger moves forward, it pushes the oil through a discharge check valve into the cylinder. The suction valve ball is within the chamber and opens with each draw of the plunger. The discharge valve ball is outside the chamber and opens when the oil is pushed into the cylinder. At this point the suction ball within the chamber is forced shut and oil pressure builds in the cylinder. *(http://hydraulic-equipment-manufacturer.blogspot.com/p/hydraulic-jacks.html)*


**Figure 3** Hydraulic Car Jack

(Photo by http://www.manufacturer.com/product/m6509561-Hydraulic+Bottle+Jack.html)

These small automotive jacks are of various different types. Bumper jacks have a protuberance that fits into a slot under the vehicle's bumper, providing some security against sudden sideways movement. Scissors jacks and ratchet jacks are other kinds of hand-operated jacks. Any time a small jack is used, it's critical that the vehicle be in a stable position on a flat surface. Be sure that the jack is pushing up against a solid frame member that will support the weight of the vehicle, or else you will need to repair more than your tire. *(http://cotsncots.com/faq-general.html)*

**Figure 4** Scissor Car Jack

(Photo by http://www.supplierlist.com/products/balmart/shrowroom.htm)

Hydraulic or air-powered jacks are an essential component of modern auto repair shops, and have been fixtures on the auto body repair scene for at least 50 years. They are most often used by professional shops and garages, although there are smaller versions that are made for the home hobbyist as well. Hydraulic jacks operate by pressurizing water in a sealed system, which provides more than enough power to lift a car or small truck into the air. Once the jack has reached its full upward extension, it is locked in position so that the under body of the vehicle is accessible for service and repairs. *(http://cotsncots.com/faq-general.html).*

## 2.2 Hydraulic System

A hydraulic jack uses a fluid, which is incompressible, that is forced into a cylinder by a pump plunger. Oil is used since it is self lubricating and stable. When the plunger pulls back, it draws oil out of the reservoir through a suction check valve into the pump chamber. When the plunger moves forward, it pushes the oil through a discharge check valve into the cylinder. The suction valve ball is within the chamber and opens with each draw of the plunger. The discharge valve ball is outside the chamber and opens when the oil is pushed into the cylinder. At this point the suction ball within the chamber is forced shut and oil pressure builds in the cylinder.

In a Bottle Jack the piston is vertical and directly supports a bearing pad that contacts the object being lifted. With a single action piston the lift is somewhat less than twice the collapsed height of the jack, making it suitable only for vehicles with a relatively high clearance. For lifting structures such as houses the hydraulic interconnection of multiple vertical jacks through valves enables the even distribution of forces while enabling close control of the lift. *(http://en.wikipedia.org/wiki/Jack_(device))*

## 2.3 CATIA Overview

CATIA is a general purpose finite element modelling package for numerically solving a wide variety of mechanical problems. These problems include: Static/Dynamic Structural Analysis (both linear and non-linear), heat transfer and fluid problems, as well as electromagnetic problems. To produce this drawing in this project, we use CATIA Version 5 Release 15 software. Under this software, we were able to use many types of function/features such as line, circle, trim, extrude, edit, polyline, arc, fillet, pad and others. *(Dr. R.Ganesan, 2007)*

### 2.3.1 CATIA

Finite element analysis software enables engineers to perform the following tasks:

- Build computer models or transfer CAD models of structures, products, components, or systems.
- Apply operating loads or other design performance conditions.
- Study the physical responses, such as stress levels, temperature distributions.
- Optimize a design early in the development process to reduce production costs.

- Do prototype testing in environments where it otherwise would be undesirable or impossible.

## 2.4 Structural Analysis

Structural analysis is probably the most common application of the finite element method. The term structural (or structure) implies not only civil engineering structures such as bridges and buildings, but also naval, aeronautical, and mechanical structures such as ship hulls, aircraft bodies, and machine housings, as well as mechanical components such as pistons, machine parts, and tools. *(Chennakesava R. Alavala, 2009)*

### 2.4.1 Types of Structural Analysis

The primary unknown (nodal degrees of freedom) calculated in a structural analysis is displacement. Other quantities, such as strains, stresses, and reaction forces, are then derived from the nodal displacements.

Static Analysis used to determine displacements, stresses, etc. under static loading conditions, both linear and nonlinear static analyses. Nonlinearities can include plasticity, stress stiffening, large deflection, large strain, hyper elasticity, contact surfaces, and creep.

Transient Dynamic Analysis used to determine the response of a structure to arbitrarily time-varying loads. All nonlinearities mentioned under Static Analysis above are allowed.

## 2.5 Experimental Methods for Determination of Stress

There are a number of methods that are used for finding the value of stress in a part. Some of the methods that are most commonly used are briefly discussed below.

*Strain Gauges:* A strain gauge may be defined as any instrument or device that is employed to measure the linear deformation over a given gauge length, occurring in the material of a structure during the loading of the structure. This definition is quite broad; in fact it covers the range of instruments included between the linear scale and the precise optical and electrical gauges now available. The many types of strain gauges available are quite varied, both in application and in the principles involved in their magnification systems. Depending upon the magnification system, the strain gauges may be classified as follows:

1. Mechanical
    - Wedge and screw.
    - Lever-simple and compound.
    - Rack and pinion.
    - Combination of lever and rack and pinion.
    - Dial indicators.
2. Optical.
3. Interferometric type.
4. Electrical.
    - Inductance.
    - Capacitance.
    - Resistance.
    - Piezoelectric.
5. Magnetic.
6. Acoustical.
    - Pneumatic.
    - Scratch type.
    - Photostress gauge.

*Photoelasticity:* this method depends upon the property of certain transparent solids by which they become doubly refractive under the action of stress, the magnitude of the optical effect bearing a definite relation to that of the stress. The optical phenomenon, known as Sir David Brewster first discovered the "photo-elastic effect" in 1816 in sheets of stressed glass. Brewster, however, did not succeed in obtaining a uniform stress in his model and was not able to make any quantitative estimate of the relation between the stress and the optical effect produced. In 1820 Biot demonstrated that a strip of glass became doubly reflecting when set into a state of longitudinal vibrations. Fresnel attempted to measure the changes in the velocities of the two oppositely polarized rays in glass without any decisive results. Neumann presented the first theory of the photoelastic effect in 1841 and expressed the velocities of the two waves in terms of the three principal strains in the medium. In 1853, Maxwell presented a theory in which the velocities were related to the principal stresses. Both these theories produced relations of precisely similar form and were equally applicable to an isotropic linear and elastic material under any system of combined stress. *(Rao, 'The finite element methods in Engineering' Pergamon Press, 1982)*

## 2.6 Numerical Methods for Analysis

In engineering analysis a theoretical model was the first choice for researchers and scientists because of accurate and unique solution. But in pragmatic design problem, the theoretical model was scarcely utilized to predict physical response because of the complex geometrical design and path. Therefore powerful numerical method was introduced to engineers to overcome difficulty.

Some of the numerical approaches are

- Finite difference method.
- Finite volume method.
- Boundary element method.
- Finite element method.

In the design of engineering structures, numerical simulations play an increasingly important role. This can be attributed to the high costs or practical difficulties related to experiments, which have to confront rapid advances in the computational power and the resulting decrease in the costs for computer simulations.

### 2.6.1 Finite Elements method

Finite element method has become a powerful tool for the numerical solution of a wide range of engineering problems. Applications range from deformation and stress analysis to field analysis of heat flux, fluid flow, magnetic flux, seepage and other flow problem. In this method of analysis, a complex region defining a continuum is discredited into simple geometric shapes called Finite Elements. Finite element method solves for forces and displacement over the entire object. Since most visual applications tend to be more interested over the entire object, Finite element method seems promising. Finite element method is used for solving many industrial problems like Automobile frames, optimization of mechanical parts, artificial limbs etc. Rolling mill housing is one of them.