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for Bachelor of Mechanical Engineering (Thermal – Fluid)

Signature :

Supervisor Name : Mr Safarudin Gazali Herawan

Date :

FOLDABLE ELECTRIC BICYCLE USING HUB MOTOR

MUSYRIFF BIN MUSTAFA

This report is written as a partial fulfillment of terms in achieving the award for
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Universiti Teknikal Malaysia Melaka

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“I admit that this report had been done originally from me except some of them where I have been explain each one of them with its sources”

Signature :

Name : Musyriff Bin Mustafa

Date :

Especially to my beloved parents

My respectfully lecturers

Also my faithfully friends

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In this great opportunity, I would like to thank Allah for providing me strengths to completing this report of foldable electric bicycle using hub motor. Here, I would like to acknowledge with appreciation to all those people who helped me numerous during completing this project.

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ABSTRACT

This project is purpose to create technical research for undergraduate students which have high potential in technical paper publication. Throughout this project, a Foldable Electric Bicycle will be design and analyze in order to make this project successful and reach the objective. Commonly, foldable electric bicycle use different type of electric motor as a power assist and with different method of fold mechanism. In this project, there are two main consideration in order to design the bicycle which is power assist (electric motor) and folding method. For power assist, this project is using hub motor that attached at the rear wheel. In order to design a small bicycle, a folding method and material that will be used in this project need to be analyze. Based on this research, a small electric bicycle will be design as a prototype and the motor performance and strength of bicycle frame will be analyzed. The analysis on bicycle frame had been done by using Cosmos Solidwork 2010 software to know whether the frame design is acceptable.

ABSTRAK

Projek ini adalah bertujuan untuk mewujudkan penyelidikan teknikal bagi pelajar prasarana yang mempunyai potensi besar untuk penerbitan kertas teknikal. Sepanjang projek ini, sebuah basikal electric boleh lipat akan dicipta dan dianalisis untuk memastikan kejayaan dan objektif projek ini tercapai. Pada amnya, basikal jenis ini menggunakan pelbagai jenis elektrik motor sebagai sumber untuk menggerakkan basikal dan dengan berbagai kaedah melipat. Dalam projek ini, terdapat dua perkara yg diutamakan untuk merekebentuk basikal iaitu motor elektrik dan kaedah melipat. Untuk projek ini, *hub motor* telah digunakan sebagai kuasa tambahan pada pedal basikal. Selain itu, untuk merekabentuk basikal yang bersaiz kecil, jenis bahan yang akan digunakan dan kaedah melipat akan dikaji dan perbandingan akan dibuat. Akhir sekali, berdasarkan segala kajian dan analisis yang dilakukan, sebuah basikal elektrik boleh lipat akan direka dan akan diuji. Analisis untuk mencari kekuatan kerangka basikal akan dilakukan dengan menggunakan perisian computer iaitu 'Cosmos Solidwork 2010'.

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LIST OF SYMBOLS

L	=	length
H	=	height
D	=	dimension
cm	=	centimeter
η	=	Motor Efficiency
P_e	=	Electrical Input Power
P_m	=	Mechanical Output Power
T	=	Torque
V	=	Voltage
I	=	Input Current
ω	=	Output Angular Velocity
rpm	=	revolution per minute

CHAPTER I

INTRODUCTION

1.1 PROJECT BACKGROUND

As we know, bicycling is becoming an increasingly more popular form as transportation. Besides that, the bicycle is used for recreation, transportation and competition. It let you get where you are going a lot faster and using less energy than walking or running. Basically, bicycle is made of just a few parts that we can immediately see and identified and it is a pedal driven or human powered vehicle with two wheels attached to frame, one behind and another which is required balancing by the riders.

Recently, bicycle has been equipped with electrical component to make riding easier and more enjoyable. According to the data of the China Bicycle Association, a government-chartered industry group, in 2004 China's manufacturers sold 7.5 million electric bicycles nationwide. An electric bicycle is simply a bicycle with an attached motor which assist the riders. Electric bicycles use rechargeable batteries, electric motors and some form of control for powering the rear wheel. An electric power assist system may be added to almost any pedal cycle using chain drive, belt drive, hub motors or friction drive. However, the frame of prior electric bicycle is fixed and its storage may occupy a relatively large space and difficult to carried into building, workplace or

onto public transportation. So, it's not convenient for living environment of the big city nowadays. Thus, based on that problem, the folding electric bicycle was created.

Earlier invention of folding bicycle was recorded in early 1900. A folding bicycle incorporates special design features enables the bike to fold into a compact form. When folded, the bikes can be more easily carried into buildings, into workplace or onto public transportation. Folding mechanisms themselves are highly variable, with each design offering a unique combination of folding speed, folding ease, compactness, engineering, ride, weight, durability and price.

The foldable electric bicycle uses a combination of folding frame and powered assist by electric motors. Thus it will give advantages because it not required human energy to drive it, reduced storage space and being ease of movement. Besides that, this type of bicycle is suitable for living environment at the big city. Another advantage for this type of bicycle is based on energy cost. The energy costs of operating electric bicycles are small, but there can be considerable battery replacement costs. Riding an electric bicycle to work or to the store instead of taking a car has long term financial gains.

1.2 OBJECTIVES

The main objectives of this project are:

1. To design a small electric bicycle
2. To analysis the performance of motor starter
3. To analysis the strength of proposed bicycle frame

1.3 PROBLEM STATEMENT

Nowadays, a foldable electric bicycle is become increasingly popular around the world. There a lot of invention of folding electric bicycle in the market with different size, power assists material usage and folding mechanism. However, not all the invention is perfect and suitable for all situations. For example, larger size of bicycle have a better ride and better handling but it difficult to carried into public transportation even in folding form and if the design too small, it will sacrifice ride quality due to smaller wheel and to steering. Besides that, some of the product in the market takes a longer time to fold into compact form. So, this will be part to think the solution for related problem. Below is the listed of problem in this study.

1. Selecting the suitable size
2. Creating a folding mechanism that will decrease time to fold
3. Selecting the right material for frame to reduced weight but can support variable load.
4. Selecting of proper electric motor as a power assist

1.4 SCOPE

The focus of this study is to do a researching and developing a foldable electric bicycle in order to reduced storage space and being ease of movement. In this project making there are several things which are been considerate and which are not been considered. This research will focus on several aspects.

1. Ergonomic design of bicycle frame
2. Performance analysis of electric motor (maximum speed and motor efficiency)
3. Material selection for bicycle frame
4. Analysis on reaction force on proposed bicycle frame

1.5 PSM FLOW CHART

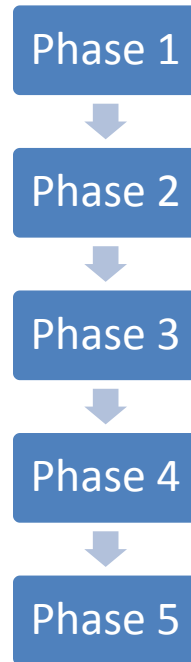


Figure 1.1 Undergraduate Project Flow Charts

Figure 1.1 shows that the flow charts for PSM 1 implementation. As preliminaries, the flow starts with phases 1 which include selecting the title of the project. In phase 2, all the possible project background, objectives, scope and problem statement will be determined. Then, preparation for literature review regarding to existing product and subject study is stated in phase 3. In phase 4, the expected methodology of the project and new design was created based on the research will be completed. Finally, phase 5 or final phase includes the result and discussion of the project and preparation for final project full report.

CHAPTER II

LITERATURE REVIEW

2.1 History of the Bicycle

The first predecessor of the bicycle that exists is a wooden horse developed in 1700's in France. A toymaker come up with the idea of placing a wheel on the bottom of his horse, so that a child could propel himself forward with his feet. After this creation, in 1817 Baron von Drais invented the Draisienne, a steerable bicycle. It was almost completely made of wood, and having no pedals, riders propelled it by pushing their feet against the ground. The purpose of this invention is to help him move around the Royal Gardens when he was in hurry.

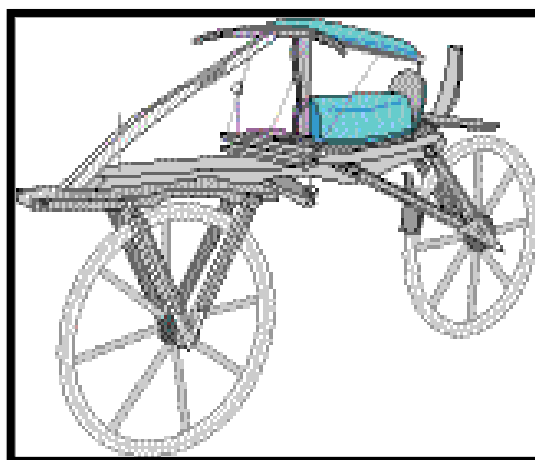


Figure 2.1: The Draisienne invented by Baron van Drais
(Sources: <http://images.google.com>)

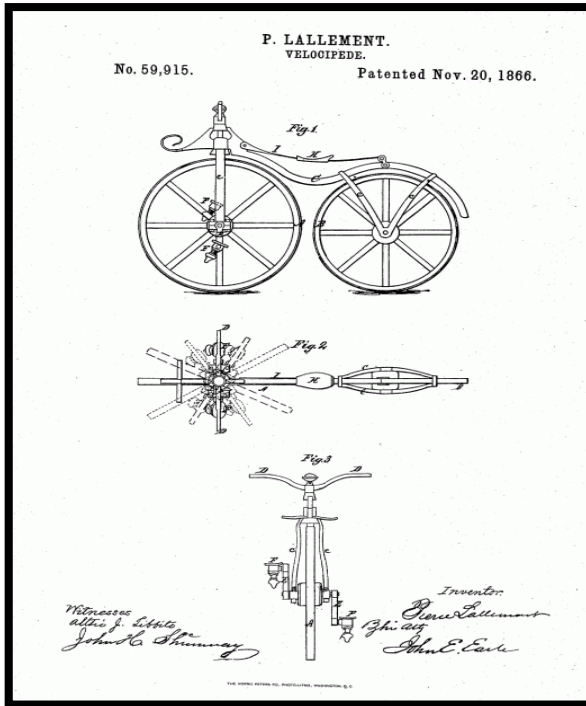


Figure 2.2: The Velocipede
(source: <http://images.google.com>)

The next appearance of a two wheeled riding machine was invented in 1865, pedals were applied directly to the front wheel. This machine was known as the Velocipede, but was popularity known as the bone shaker because it also made entirely from wood. Wooden wheels clattering over cobblestone and dirt roads often lead to riders falling off and getting injured. For this reason, a lot of modification and improvement in design of bicycle is done to create a proper bicycle until in 1870, when the first all metal machine appeared. The pedals were still attached directly to the front wheel with no freewheeling mechanism. Solid rubber tires and the long spokes of the large front wheel provided a much smoother ride than its predecessor. This machine was the first one to be called a bicycle (two wheels). After that, the bicycle through a lof of modifications and improvements to satisfied the riders.

In the 1890s, electric bicycles were documented within various U.S. patents. For example, on 31 December 1895 Ogden Bolton Jr. was granted U.S. Patent 552,271 for a battery-powered bicycle with “6-pole brush-and-commutator direct current (DC) hub motor mounted in the rear wheel.” There were no gears and the motor could draw up to 100 amperes (A) from a 10-V battery. The electric bicycle is a bicycle with an attached motor used to power the vehicle, or to assist with pedaling. This invention led others inventor to produce other type of electric bicycle by using a different types of power assist. The latest type of bicycle is the foldable electric bicycle which is the frame can be fold into compact form to make it easier to store and carried into building or public transportation.

Today, the electric bicycle becomes popular around the world. It was reported that in 2003 output of electric bicycle in Japan, USA, Europe and Taiwan was 250,000, 150,000, 100,000 and 100,000 pieces, respectively. If China is excluded, then the global total output of EB was 600,000 in 2003. In the same year electric bicycle output in China was 3.6 million, which is 6 times higher than global total. (source: Bicycle Retailer and Industry News)

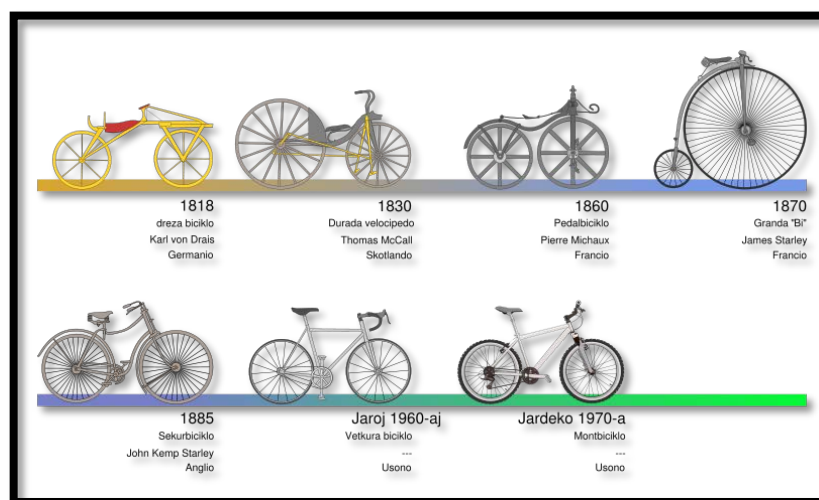


Figure 2.3 Bicycle Evolution

(source: <http://images.google.com>)

2.2 Basic Principle of Bicycle

2.2.1 Bicycle

A bicycle is a pedal-driven, human-powered vehicle with two wheels attached to a frame, one behind the other. A person who rides a bicycle is called a cyclist or a bicyclist. The coolest thing about a bicycle is that it lets you get where you are going a lot faster and using a lot less energy than if you were walking or running. There are no covers or sheet metal hiding any of the working parts that propel you down the road. Bicycles are made of from just a few parts that we can immediately we can see and identify as shown below:

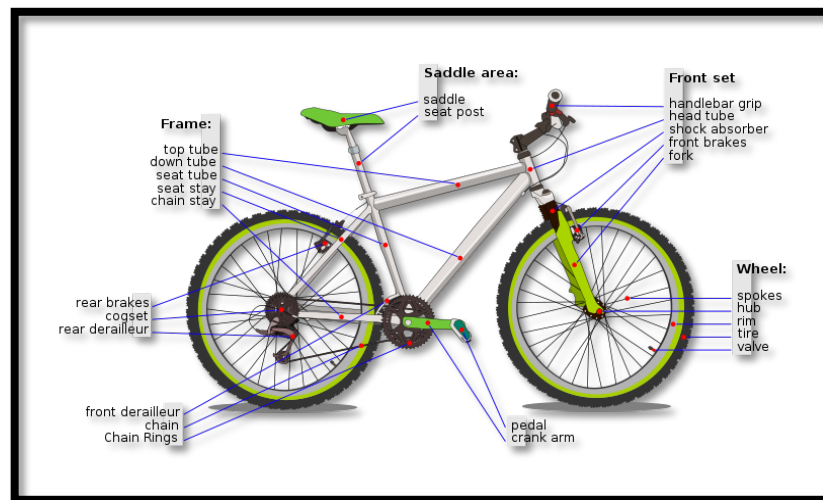


Figure 2.4 Main component of bicycle

(Source: <http://en.wikipedia.org/wiki>)

1. Frame

The frame is the core part of a bicycle which wheels and other components are fitted. The most common frame design is based on the safety bicycle and consists of two triangles (figure 2.5); a main triangle and a paired rear triangle. The main triangle consists of the head tube, top tube, down tube and seat tube. The rear triangle consists of the seat tube and pair chain stays and seat stays.

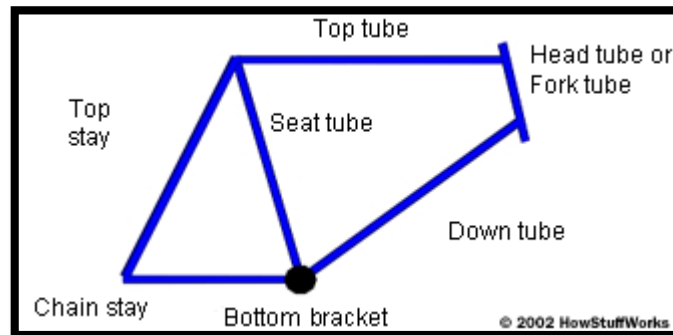


Figure 2.5 Standard Bicycle Frame

(source: <http://adventure.howstuffworks.com>.)

Generally, bicycle frame is made of metal tubes that were welded together as a one part. Mostly, the tube of the frame is made of steel because it not expensive, strong, and easy to work compare to other types of metal.

2. The wheels

The wheel axle fits into dropouts in the frame and forks and it was made of a hub, the spokes, the metal rim and the rubber tire.

3. The Seat and Seat post

4. The handlebars and the Handlebar stem