UNIVERSITI TEKNIKAL MALAYSIA MELAKA

STUDY ON THE EFFECTIVENESS OF BICYCLE TIRE TO SUPPRESS ROAD TRANSMITTED VIBRATION

This report submitted in accordance with requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor's Degree in Mechanical Engineering Technology (Maintenance Technology) (Hons.)

by

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APPROVAL

This report is submitted to the Faculty of Engineering Technology of UTeM as a partial fulfillment of the requirements for the degree of Bachelor of Mechanical Engineering Technology (Maintenance Technology) (Hons.). The member of the supervisory is as follow:

……

(Project Supervisor)

ABSTRAK

Dalam asas-asas getaran, analisis spektrum getaran adalah perlu untuk menentukan ciri-ciri kejadian kegagalan dengan menggunakan perisian yang betul. Pemantauan getaran adalah salah satu kaedah untuk mendapatkan apa-apa maklum balas data untuk penilaian analisis. Sebahagian daripada kaedah pemantauan menggunakan transduser seperti meter pecutan untuk menangkap tindak balas tingkah laku. Walau bagaimanapun, dalam pemantauan spektrum getaran, terdapat keputusan kes-kes dengan kesan-kesan yang dikenali sebagai kebolehpindahan getaran. Kajian ini adalah untuk menjalankan penilaian eksperimen untuk menganalisis prestasi dan kesan yang berlainan saiz tayar basikal di dalam kebolehpindahan getaran pada Basikal Gunung terhadap tubuh manusia. Meter pecutan berasaskan magnet ekapaksi telah digunakan untuk menangkap tindak balas tingkah laku untuk analisis jawapan kebolehpindahan getaran yang berlainan saiz tayar. Pemasangan meter pecutan dipasang pada rekaan pendakap yang dibuat di aci penggantungan garpu dan di bawah pelana silinder aci. Basikal Gunung telah digunakan sebagai subjek ujian bagi penindasan tayar ini pada jarak yang tertentu dalam masa tertentu yang berselang di eksperimen . Kaedah kajian yang dibuat melalui pemasangan pecutan atas penyangga dibuat, melalui kabel BNC sebagai sambungan terhadap penganalisis isyarat kemudian ke arah peranti pemprosesan tugas dengan ansuran perisian analisis spektrum getaran. Pelaksanaan persamaan kebolehpindahan getaran sebagai penentuan kebolehpindahan diambil kira. Spektrum getaran yang diperolehi dibandingkan dan menganalisis secara logik mengenai penggunaan lebar yang berbeza tayar tetapi diameter sama pada permukaan turapan berterusan dan kelajuan tetap. Dari eksperimen dikaji ini, kesimpulan tentang prestasi dan kesan yang berlainan saiz tayar basikal merujuk pada kebolehpindahan getaran terhadap Basikal

Gunung kepada tubuh badan manusia telah dibuat dan ini boleh dirujuk oleh penyelidik kajian yang lain mengenai prestasi tayar dari segi tindak balas getaran.

ABSTRACT

In vibration fundamentals, the analysis of vibration spectrum is necessary to determine the characteristics of failure occurrences by using proper software. Vibration monitoring is one of the methods to obtain such data responses for the analytical assessment. Some of these monitoring methods use a transducer such as accelerometer to capture the behavioural responses. However, in monitoring vibration spectrum, there are such cases results with consequences which is known as vibration transmissibility. This study is to conduct an experimental assessment in order to analyze the performance and effect of different sizes bicycle tire on its vibration transmissibility on a Mountain Bike to the human body. Uniaxial magnetic based accelerometers were used to capture the behavioural responses for the analysis of its vibration transmissibility responses of different sizes tire. The assembly of accelerometers is fabricated on a bracket made at the suspension fork shaft and at seat post shaft. Mountain Bike was used as a test subject for the suppression of these tires at a certain distances within certain time interval experimented. The method of the study is made through assembly of accelerometers on the brackets fabricated, through BNC cables as a connection towards signal analyzer then towards task processing device with installment of vibration spectrum analysis software. The implementation of vibration transmissibility equation as a determination of the transmissibility was employed. The vibration spectrum obtained was compared and analyzed coherently on the use of different width of tire but same diameter at a constant pavement surface and constant speed. From this experimental studied, the vindication of the performance and effect of different sizes bicycle tire on its vibration transmissibility on a Mountain Bike to the human body has been made and this could assess other researcher on the study of tire performances in terms of vibrational responses.

DEDICATION

I would like to dedicate the hardship in this project research to my beloved parents, my supervisor, Mr Ahmad Yusuf Bin Ismail, test device supplier, IR Mazlan Bin Ahmad Mansor, and to all my family member and friends for supporting me from the beginning till the completion of this project.

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To all individuals who helped me in any way, but whose name is not mentioned here, I thank all of you and your assistance is much appreciated.

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LIST OF ABBREVIATIONS, SYMBOLS AND NOMENCLATURE

ADAMS®	-	Multibody Dynamics Software
LifeMOD®	-	3-D Human Body Computer Model
BNC	-	Bayonet Neill–Concelman
FFT	-	Fast Fourier Transform
PSD	-	Power Spectral Density
SPA	-	Suspension Performance Advantage
VCI	-	Vibrational Comfort Index
F	-	Force
m	-	Mass
p	-	Momentum
v	-	Velocity
a	-	Acceleration
t	-	Time
k	-	Spring Stiffness Coefficient
x	-	Displacement
X	-	Displacement of the Function
$\dot{X}$	-	Velocity of the Function
$\ddot{X}$	-	Acceleration of the Function
X_0	-	Displacement Minimum Value
ω	-	Angular Momentum
f	-	Frequency
T	-	Period
T	-	Vibration Transmissibility
ω_n	-	Natural frequency
c	-	Damping Loss Factor
ξ	-	Damping Coefficient

CHAPTER 1
INTRODUCTION

1.1 Case Study Background

Bicycle is categorized as the one of the non-motorist transportation. Throughout the years bicycle has been much popular among community in order to fill up their sports activity or even on their needs of recreation. Some cases, bicycle is the most necessary transportation in this modern day due to a hectic road on organizing daily activities. These statements are in relation towards the following Figure 1.1 and Figure 1.2

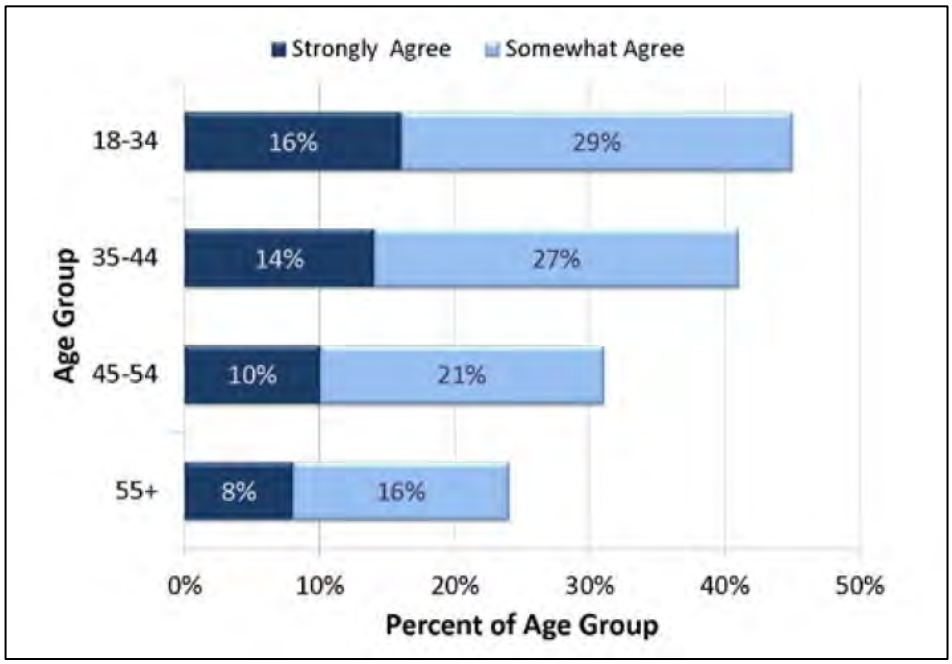

Figure 1.1: Agreement of Reducing Driving Among Ages (Davis, et al., 2012)

On Figure 1.1, Davis, et al. (2012), discovered that between elders and adolescence, agreement of reducing driving had been much popular and demanding among adolescence ages. The group of age between age 18 to 34 years old in the survey with the addition of "somewhat agree" and "strongly agree" criteria has the highest average of acceptance in reducing driving. This results could be conclude that most citizen on that particular state which are younger than 34 years is losing interest in driving such motorist transportation due to hectic road on completion of their daily activities.

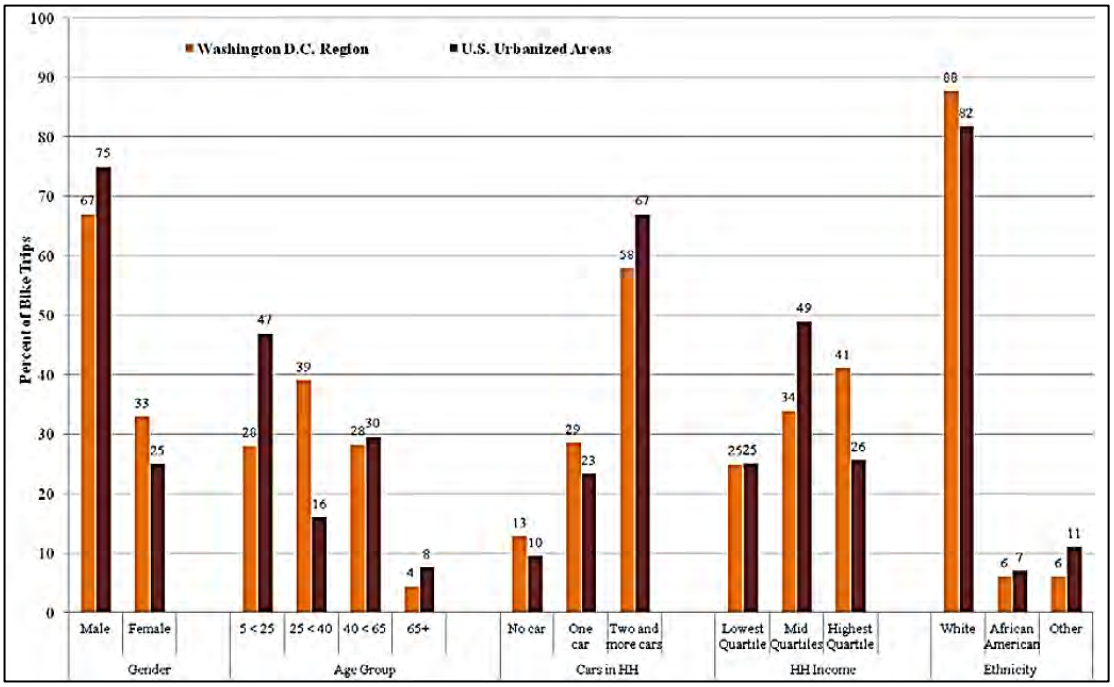

Figure 1.2: Share of bike trips by socio-demographic indicators in the Washington, D.C. region compared to the U.S. national averages for urbanized areas (Buehler, et al., 2011)

Figure 1.2 shows a survey from Buehler, et al. (2011), carried out on a selected city region in Washington D.C. and U.S. urbanized area to study the bike trips on their determination of trending and cycling among community. According to this survey, it is linked with the previous figure where younger people are most likely to cycle compared to the elderly. Based on this bar chart, cycling is most likely to be famous these days on this modern era. Therefore, the quality of such product regarding bicycle should be more effectively in state to reduce maintenance and

increase performance for the best of all riders. Therefore, the study on the effectiveness of bicycle tire to suppress road transmitted vibration to the human body will be conducted to ensure the beneficial in terms of cycling performance, comfortability, efficiency, satisfaction and harm free is achievable.

1.2 Mountain Bike History

According to Strickland (1998), mountain biking were first began in the 19th century between 1971 and 1974 in Marin Country, California. Using old wheeled junk bikes, mountain biking had become a sport to coast down the side of a mountain. The sport originally began with a local road racers group whereby they were looking for shelter on the usual grind of their training regimen. They travel on these "klunkers" or "ballooners" as they were summoned and hammered, flew, crashed, and free-wheeled them down the hills.

One of the founders of mountain bikers, Joe Breeze, invented the first true mountain bike frame in 1977. According to him, "people think there was some marketing genius behind the development of the mountain bike, but we were having fun", said Joe Breeze (Strickland, 1998).

The marketing entrepreneur's development of mountain bike equipment was also indulged by the pioneers of mountain bikers in that era. With their enthusiasm in the mountain biking sport they crafted, they soon realized the need of improvement in terms of equipment that eases their sport burden. Two of the early mountain bikers, Gary Fisher and Joe Breeze, began to think of ways to invent a bike that would advantage the rider to get back up the hills that they rode down and that does not need to be replaced or repair after every travels. The first multiple speed bike was invented by Gary Fisher. Its weight is about 41 lbs with a totally different geometry which had a triple crank on the front and five cogs on the back (Moore, 2005). Joe Breeze invented a bike that is addressed as the "Breezer" which he developed the

first mountain biking frame. Also, it was also less weighted and more durable than the old “klunkers”.

For the past twenty years, developmental of mountain bikes had become more popular in engineering rather than the past hundred years of road bikes (Richards, et al., 1997). Now, there is a competition between multiple, multi-million dollar companies to develop the best ride for mountain bikers with modern technology. With the discovery and researched of new material throughout the time, latest frames are made out of carbon fiber material that weights of only 4 lbs or even made out of alloy material that produce a soft feel over rough surfaces, and is precisely stronger than steel and incomparably in its weight. Bikes manufactured had changed from pioneer bike (Gary Fisher’s 41 lbs, 15-speed) to modern bikes today that gives out a 27-speed of weights of only 19 or 20 lbs.

Mountain Biking nowadays had become popular sports to the public that new country and city parks are opening because they have the perfect terrain and distance trail for riding mountain bikes. Also, mountain bike’s multiple gears and its durability has also enthusiast among children to own one. The popularity stage of mountain bike is astonishing if by comparing to its first existence three decades ago. As all citizens are seeking for a new fun activity and stay in good shape, mountain biking are becoming more popular in its consideration of accepting every year.

1.3 Mountain Bike Tires

Mountain bike tires are important for rider stability, grip, traction, and comfortability or even performance when cycling along to travel among distances. These tires generally made up of natural rubber which different type gives different design on its surfaces. These designs depend on type of terrain to travel. There are three mountain bike tires that will be studied in this project which are Maxxis Cross Mark (wheel size 26, width 2.1), Michelin Wild Racer (wheel size 26, width 2.0), and Maxxis Larsen TT Exeption (wheel size 26, width 1.9).

1.3.1 Maxxis Cross Mark

Maxxis Cross Mark tire is said to be a very fast and great value tire, and is suited to cross country racers with correlation to the best in dry condition. It is said that Maxxis Cross Mark delivers to be outstanding straight line speed on hardpack, but can be totally lethal in damp woods. However, this tire has its deficiency which is that almost continuous square block centerline is not only holds mud in the wet, but it slips wildly at any hint of a root. This tire was designated for the Swiss cross country superhero Christoph Sauser. (Bike Radar, 1985-2014)

1.3.2 Michelin Wild Racer

Michelin is one of the oldest names in manufacturing tire and has been making mountain bike tires for a long time. The Michelin Wild Race'R Ultimate is the new tire used for cross-country racing. During the developmental process, engineers had focused on the objective of delivering a superior dry-terrain performance. The tire's strengths include its less weight, speed, and grip and puncture- resistance. In size 26×2.10, the tubeless-ready version of the tire has weights of only 415 grams. To withstand punctures, this exceptionally less weight is obtained without even sacrificing the tire's ability. Bikers Fabien Canal and Fanny Bourdon, the top-three World Cup finishes, attest to the tire's magnificent performance levels. (Invenda Corporation, 1996-2014)

1.3.3 Maxxis Larsen TT Exeption

Maxxis tire weighing at a claimed 520g per tire, the 120 TPI Kevlar beaded 26x2.0 tire certainly fell within the lighter category of XC tires. For the 1.90 version, it has a weight of 424.5g; about 25g below the manufacturer's claimed weight. Even

on a variance of 10%, this tire is relatively light for its category. The nearest comparison is within the Hutchinson Python Airlights, but the TTs cost is much more less. The thread design on these tires designed like old school era, given that most other tires in the market currently all display rather much more interesting, which some may have aggressive thread patterns. The astonish value that were manufactured on this tire are the interesting graphics and colors on the sidewall. (Togo Parts, 2001-2014)

1.4 Bicycle Suspension

Bicycle suspension is the system used to expel the rider and bicycle in order to provide sheathe among the "one-obscured" subject from the terrain roughness. The system of bicycle suspension is used primarily on mountain bikes (Titlestad, et al., 2003); however it is also common in hybrid bicycles (Du, et al., 2009). Several bicycle suspensions are assembled in a variety of concept and design such as front suspension, rear suspension, suspension seatpost, suspension saddle, suspension stem (now uncommon), and suspension hub.

A "hardtail" is known as an assembly of bicycles with only front suspension and "full suspension bikes" are known as an assembly of bicycles with suspension in both the front and rear of the bicycle (Titlestad, et al., 2003) as shown in Figure 1.3. It is said to be "rigid" when the bicycle has no suspension and bicycle with only rear suspension are uncommon nowadays. A bicycle suspension main objective is to provide better performance and comfort towards the rider which has become an additional aspect in manufacturing racing bicycles (Vanwalleghem, et al., 2012). However, some cases involving the improvement of traction and safety by eases in keeping one or both wheels in contact with the terrain (Petrone & Giubilato, 2011).

Figure 1.3: 2009 GT Force 1.0 Full Suspension Mountain Bike

(Source: <http://www.performancebike.com>)

1.5 Problem Statement

In science, such transmissibility of vibration benefits the usage of it, but some vibrations results in up to catastrophic disaster standard. However, in this project, three types of tires on its size and design are to be examined and carefully understand the purposes of it.

In vibration, there are deficiencies such as the transmissibility of vibration towards human body in correlation towards organ or even bones. This transmissibility causes such consequences regarding to health and satisfaction. Health consequences towards vibration transmissibility can lead to very unacceptable cases such as cracked bone or such medical accidents that result in crucial need of treatment. This state of the art will contribute through a chain reaction effect that is the need of wealth management. In the end, it will result in the demand of health and wealth of a subject survival.