THE DESIGN AND ANALYSIST OF A LOW COST TIRE ENDURANCE TESTING MACHINE FRAME

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ABSTRACT

Testing machines are becoming increasingly important in the tire industry. Today the development period for new vehicles is less than two years. The number of sports cars and cross-country vehicles with four-wheel drive is growing and these require tires with better on-road performance as well as off-road properties. The endurance tester has been designed to determine the service life of tires. This tire testing machine enables to test the durability of the tires with a combination of internal pressure of tire, loading force and speed of rotation. Of course the impact on the tire should be way higher than in reality to reduce the time needed until the tire shows malfunctions such as buckling. The tire endurance testing machine selected is Drum Tire Testing Machine. But, the costs for this tire testing machine found in industries are too high and expensive.

ABSTRAK

Kepentingan mesin penguji tayar meningkat dengan pesatnye di dalam industri pembuatan tayar. Kini, tempoh masa pembangunan kenderaan-kenderaan baru ada kurang daripada dua tahun. Bilangan pertambahan kereta lumba dan kenderaan pacuan empat roda dengan pesatnyea memerlukan tayar yang memiliki prestasi yang tinggi samada untuk kegunaan di atas jalan ataupun jalan yang tidak berturap. Oleh itu, mesin penguji ketahanan tayar telah direka bentuk dan dicipta untuk menentukan ketahanan tayar itu sendiri. Mesin penguji tayar ini boleh menguji ketahanan tayar itu dari segi gabungan tekanan di dalam tayar, daya yang dikenakan terhadap tayar itu, dan juga kelajuan tayar itu berputar. Daya yang bertindak ke atas tayar itu semestinya dikenakan lebih tinggi supaya tempoh masa yang diambil untuk melihat tayar itu mengalami perubahan bentuk seperti melentik dapat dikurangkan. Jenis mesin penguji yang dipilih untuk dijalankan di dalam projek ini adalah jenis yang menggunakan drum. Tetapi, kos yang diperlukan untuk mereka bentuk mesin ini di dalam industri pada masa kini adalah begitu mahal dan strukturnya juga agak besar.

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LIST OF SYMBOLS

W	=	weight
m	=	mass
g	=	gravity acceleration
$\emptyset$	=	diameter of cylinder

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LIST OF ABBREVIATION

SABS	South African Bureau of Standards
UN ECE	United Nations Economic Commission for Europe
ISO	International Standard Organization
AISI	American Iron and Steel Institute
m	meter
mm	millimeter
kg	kilogram
N	Newton
C	Carbon

CHAPTER 1

INTRODUCTION

1.1 General Overview

While the automobile was invented in the late-1800s, the study of automobile vehicle dynamics did not gain momentum until the 1920s and '30s. One of the earliest publications on tire behavior was by Broulhiet in 1925 in which he established the concept of the slip angle. Until that time, the tire was largely seen as a suspension component (vertical response was studied) and as a source of power loss (rolling resistance). The force and moment characteristics of interest to modern vehicle dynamic were only beginning to be explored.

Drum testing of tire forces and moments grew throughout the 1930s. By 1939 a person who his name is Bull was able to dream a full six component drum-type test machine. While tire testing on drums is relatively simple, every drum-type test machine has the weakness that it presents a curved surface to the tire footprint. This curvature alters the pressure distribution in the footprint from that seen on the (nearly-flat) roadways, and thus produces somewhat different outputs than would be seen on a flat road.

1.2 Problem Statement

This tire testing machine enables to test the durability of the tires with a combination of internal pressure of tire, loading force and speed of rotation. Of course the impact on the tire should be way higher than in reality to reduce the time needed until the tire shows malfunctions such as buckling. However the costs for this tire testing machine in the industry is too high and expensive.

1.3 Objective

The objective for this project is to develop a low cost tire endurance testing machine (Drum Testing Machine) with similar abilities found in the industry.

1.4 Scopes

The project scopes of were:

1.4.1) Design a tire endurance testing machine frame.

1.4.2) Simulate the structure in computer software like COSMOSWorks and SolidWorks to the main frame.

1.4.3) Analysis the tire endurance testing machine frame.

CHAPTER 2

2.1 Tire Endurance Tester

The endurance tester has been designed to determine the service life of tires. The test procedures of this machine are in compliance with DOT, SAE and ECE standards. No special mounting is required as the tester is of a rigid, free-standing design. Integration of top-quality electronic components guarantees a precise test run. The real-time test controller integrated in a flexible industrial PC provides a user friendly, menu-operated control system that is fully digital. The machine can be configured in several ways: one or two car tire stations one or two truck tire stations, or a combination of both. A number of options can be included, for example slip, camber, deflection, temperature/circumference/rolling resistance measurement, pressure regulation or foot printing.

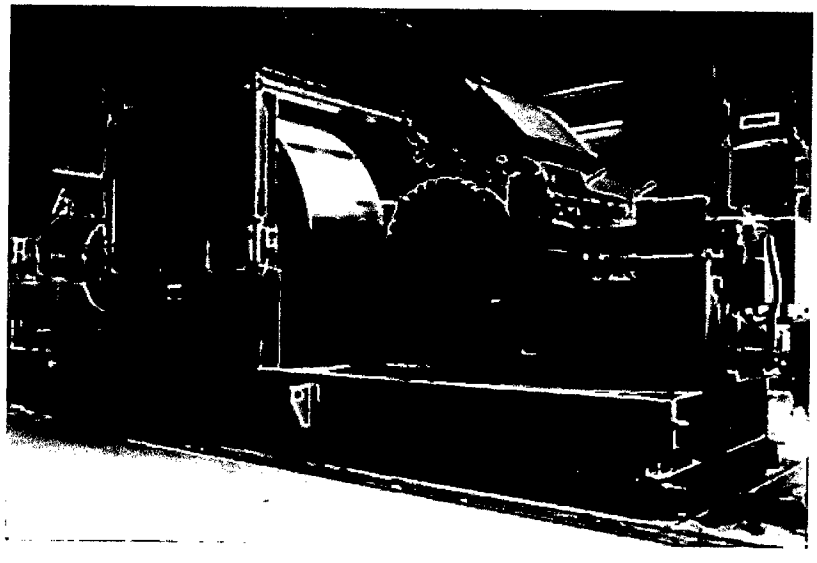

Figure 2.1: Tire endurance tester

2.2 Force And Moment Testers

The force and moment tester meets all requirements for tire characteristics, such as dynamic altering of the slip angle, camber angle adjustment and hub drive. All moments and forces are measured, making this equipment suitable for testing tires as well as for use in their development. A five-component measuring hub records all moments and forces in detail. The industrial PC in the control cabinet stores the data. This sophisticated measuring system is ideal for the development of high-performance tires.

2.3 Noise Testers

A necessary property of modern tires is a low noise level in all situations. The frame and drive train of the noise tester are situated in a pit and the bearing on the road wheel only develops low running noise, thereby creating the optimum conditions for measuring tire-generated noise. The tire to be tested is situated in a semi-anechoic room. To eliminate loading noise, electric motors are used instead of hydraulics. The control cabinet is outside the room and is able to execute test runs automatically. The option of adjustable slip and/or camber for realistic simulation completes the machine.

2.4 Universal Tire Testers

The universal tire testing machine can test passenger and truck tires for four distinct operational characteristics: load deflection, bead unseating, plunger energy, and footprint. Additional tests include tread contact area ratio (image scanning by camera) and the dynamic behavior of the tread pattern under load. This machine provides many testing options in one machine, offering considerable savings in space and economic efficiency

2.5 Tire Construction

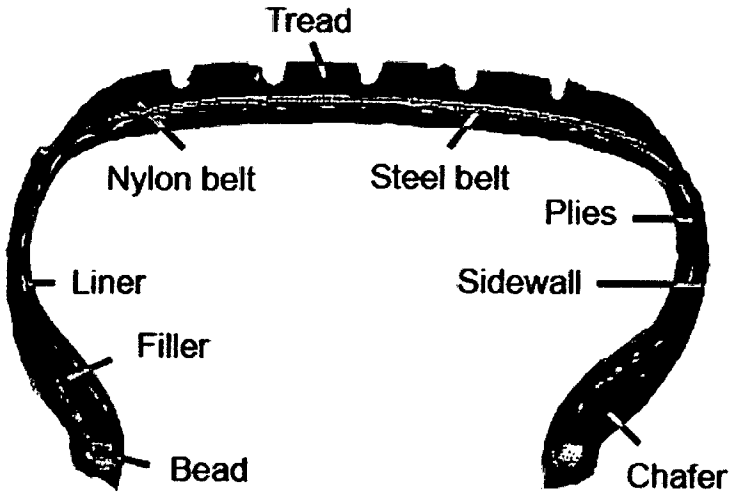

Figure 2.2: Tire construction

2.5.1 Tread

Tread is the part which comes into contact with road surface. It protects the carcass and provides high grip, longer life, maneuverability and durability.

2.5.2 Steel Belts

This provides stiffness to the tread and protects the carcass

2.5.3 Sidewall

Sidewall is the most flexible part of the tire. It protects carcass and provides comfortable ride.

2.5.4 Plycord

Plycord is the main body of a tyre. It sustains the inflation pressure and endures load and road

2.5.5 Bead Filler

This provides high durability & maneuverability

2.5.6 Bead Wires

It holds the tire on rim

2.5.7 Chafer

Chafer protects plycord at the bead area from the heat generation developed due to the abrasion of bead and rim flange.

2.6 Tire Size

On the sidewall of a tire we will find various codes and markings. The list below aims to simplify the coding system and allow the user to understand the valuable information imprinted on the sidewall of any tire.

Tire sizes are made up of different numbers and letters. For example: the tire size **205/45R16** 79V is made up of the following information:

205 Width (The tire section WIDTH in millimeters, mm)

45 Profile (The aspect ratio in %. height of the sidewall / tire width)

R Radius

15 Rim diameter in inches

79 Load index

V Speed Rating

Figure 2.3: Tire Size

Table 2.1: Tire speed symbol and speed rating

TIRE SPEED SYMBOL	TIRE SPEED RATING
S	180 km/h or 112 mph
T	190 km/h or 118 mph
U	200 km/h or 125 mph
H	210 km/h or 130 mph
V	240 km/h or 149 mph
W(ZR)	270 km/h or 168 mph
Y(ZR)	300 km/h or 186 mph
ZR	Above 240 km/h or 149 mph

2.7 Basic Ingredients to Make a Tire

Fabric, steel, nylon, aramid fiber, rayon, fiberglass, or polyester (usually a combination polyester fabric in the body plies and steel fabric in the belts and beads of most radial passenger tires).

Rubber : natural and synthetic (hundreds of polymer types)
Reinforcing chemicals : carbon black, silica, resins
Anti-degradants : antioxidants, ozonants, paraffin waxes
Adhesion promoters :cobalt salts, brass on wire, resins on fabrics
Curatives : cure accelerators, activators, sulfur
Processing aids : oils, tackifiers, peptizers, softeners .

2.8 Tread Design

The rubber blocks otherwise called tread blocks are the ones that come into contact with the ground and determine how well the tire grips the road. The more tread blocks there are, the better the grip.

The valleys and grooves are hard at work when it rains. Water on the tire is channeled into them where they are stored. As the tire rolls, the water is released from the back. If there are not enough grooves, water cannot be dispersed from the surface of the tire which can cause the tire to lose contact with the road. This is known as aquaplaning.

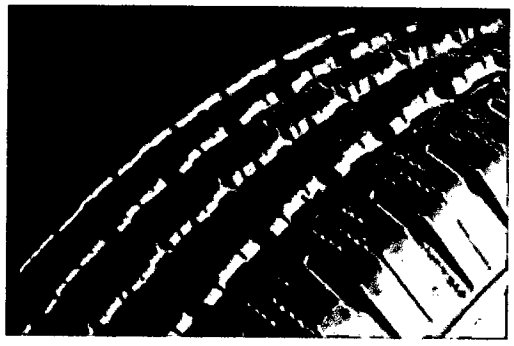

Figure 2.4: Tread design

So, the blocks provide better grip in dry conditions while the grooves and valleys help disperse water, allowing for better control and handling in wet conditions. To ensure the tire offers a safe ride, there needs to be a balance between the blocks and the grooves.

The traction of a tire on a dry surface is diminished by any tread pattern. Slick which is the treadles tire at the race car such as at the F1 car, generate the best dry grip because of the uninterrupted support of the lateral and longitudinal shear forces produced by the road during cornering, braking and acceleration. Any tread pattern creates voids in the rubber surface leaving areas of rubber unsupported in shear and lowering the area in contact with the road.

Tires produce more grips when there is more tread area in contact with the road. This is due both adhesion and mechanical keying of the rubber to the road.

2.9 Tread Pattern for a Wet Surface

Tread pattern greatly improves wet grip. When a tire is moving so fast the water cannot get out of the way the tire can ride up on the water in what is called aquaplaning, a condition of very low grip and loss of control. Tires designed for use on road cars need a compromise tread design providing performance in both wet and dry conditions.

The role of the tread pattern on a road tire or a wet weather race tire is to help eliminate the water from between the tire and the road surface. Grooves in the tread rubber provide channels for water squeezed out from the contact patch. These grooves also raise the pressure between the tire and the road by lowering the area of contact.

2.10 Tire Noise

For road tires noise is an issue. The tire noise produce because at the tread patent, there are different sized tread blocks. If all the blocks are the same size the noise produced by their interaction with the road has a single tone. Varying block sizes produce a range of tone called white noise which does not sound as loud to humans. The sound level is the same, but the noise is not so disturbing.

2.11 Contact Patch Load Effects

Fatigue strength of the tire cords, internal pressure, vehicle speed, time spent at that speed, load on the tire and length of the contact patch are the critical specifications for the tire. The tire designer must choose the best compromise among many choices of materials, cord angles and manufacturing process in order to create a tire with the performance and durability required for a specific application. And the manufacturing cost has to be low enough for the product to be profitable.

Those design specifications listed (internal pressure, diameter of the wheel rim, tread width and section height) determine the size of the contact patch of a tire at a given vertical load. The internal pressure in the tire actually supports the vertical load bearing on the tire through the contact patch.

From the tire's point of view there is a distortion pattern rotating around the tire as it rolls. This flexing in the tire structure creates due to the internal damping in the rubber. This flexing can also cause fatigue failures in the structure and fatigue failure is the main concern of the tire designer.

2.12 Rolling Resistance

We know that a load distorts the structure of a tire in the contact patch where the tire comes in contact with the road. Since the tire is a composite of textile cords in a rubber matrix covered with a rubber tread and know the rubber absorbs some energy when deflected by a force, we can expect that a rolling tire would absorbs some energy. In a simple rolling tire this is called rolling resistance and it increases with speed and load.

An increase in load at constant internal pressure and constant speed causes more tire distortion which increases rolling resistance. An increase in

inflation pressure at constant load and speed results in lower distortion therefore lower rolling resistance.

Rolling resistance increases with road speed. The inflation pressure rises with temperature, reducing the size of contact patch, lowering distortion and lessening the power absorption effect of hysteresis. And hysteresis in rubber goes down with increasing temperature.

2.13 Codes and Standards

To design or fabricate a machine, there are some codes and standards must be following by the designer. A standard is a set of specifications, materials, or processes intended to achieve uniformity, efficiency, and a specify quality. One of the important purposes of a standard is to place a limit on the number of items in the specifications, so as to provide a reasonable inventory of tooling, sizes and varieties.

A code is a set of specifications for the analysis, design, manufacture and the construction of something. The purpose of a code is to achieve the specified degree of safety, efficiency and performance or quality. It is important to observe that safety codes do not imply absolute safety. In fact, absolute safety is impossible to obtain.

Chapter 3

METHODOLOGY

3.1 Project Methodology

To design and analyst the tire endurance testing machine, there are some steps that must be doing. The steps include:

1. Literature review about the tire and the tire endurance testing machine.
2. Conceptual designing and sketching of the machine.
3. Computer modeling and simulation of the machine.
4. Study about the analysis.

Below are the flow charts in the development activities.