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JUDUL: EFFECT OF EXTERNAL AGENT IN THE CONTROL OF VEHICLE TYRE PRESSURE

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MUHAMMAD HAFIZ BIN AHMAD SOHAN

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

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Effect Of External Agent In The Control Of Vehicle Tyre Pressure

Thesis submitted in accordance with the partial requirements of the Universiti Teknikal Malaysia Melaka for the Bachelor of Manufacturing Engineering (Robotic and Automation) with Honours.

By

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APPROVAL

This thesis submitted to the senate of UTeM and has been accepted as partial fulfillment of the requirements for the degree of Bachelor of Manufacturing Engineering (Robotic and Automation) with Honours. The members of the supervisory committee are as follow:

……..

Main Supervisor

DECLARATION

I hereby, declare this thesis entitled “Effect Of External Agent In The Control Of Vehicle Tyre Pressure” is the results of my own research except as cited in the reference.

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ABSTRACT

The importance of tyre pressure in determining the safety of vehicle's users, riding comfort and fuel efficiency has encourages lots of researchers to come out with the most effective solutions. Though the reliability of car tyres have been improved in the recent years, a loss in tyre pressure still causes a lot of bad consequences. Therefore, the development of an effective tyre pressure monitoring system by considering the effect of external agent towards the vehicle tyre pressure might be the appropriate solutions. Research works that are related with tyre pressure is conducted to develop a deep understanding that rest as a core for this thesis work. The external agents that have effects towards the tyre pressure are identified and analyzed to determine the exact relation with the tyre pressure. The external agents will then be transformed into mathematical models that will be integrated into a driveline simulation program. SimDriveline is the feature of MATLAB Simulink that is used to develop the drivetrain system for this thesis. SimDriveline provides the mechanical simulation package that enables the simulation that can visually shows the effect of the external agents in the control of vehicle tyre pressure. The success of this thesis will prove to be beneficial to the automotive industry especially to the tyre manufacturer. Besides that, the safety of vehicle also could be improved and secured.

ABSTRAK

Kepentingan tekanan tayar dalam menentukan keselamatan pengguna kenderaan, keselesaan pemanduan dan penjimatan minyak telah mendorong golongan penyelidik untuk menghasilkan jalan penyelesaian yang paling efektif. Walaupun kebolehtahanan tayar kereta telah meningkat tahun demi tahun, kehilangan tekanan dalam tayar masih boleh mendatangkan kesan-kesan yang buruk. Oleh sebab itu, pembinaan sistem pengawasan tekanan tayar yang efektif di samping mengambil kira kesan ejen luar terhadap tekanan tayar dilihat sebagai satu penyelesaian yang sesuai. Kerja-kerja penyeledikan yang berkaitan dengan tekanan tayar dijalankan bagi membentuk kefahaman yang mendalam dan juga sebagai teras bagi tesis ini. Ejen-ejen luar yang mendatangkan kesan terhadap tekanan tayar dikenalpasti dan dianalisis bagi menentukan hubungan sebenar ejen-ejen tersebut terhadap tekanan tayar. Ejen-ejen luar tersebut akan dibentuk menjadi model-model matematik sebelum diintegrasikan ke dalam program simulasi kenderaan. SimDriveline merupakan peralatan di dalam perisian MATLAB Simulink yang digunakan bagi membangunkan sistem kenderaan untuk tesis ini. SimDriveline menyediakan pakej simulasi mekanikal yang membolehkan sistem simulasi di dalam tesis ini untuk menunjukkan kesan ejen-ejen luar terhadap tekanan tayar secara visual. Kejayaan tesis ini dijangka dapat menyumbangkan manfaat ke industri automatif terutamanya pembuat tayar. Di samping itu, keselamatan kenderaan di jalan raya juga boleh dipertingkatkan dan lebih terjamin.

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LIST OF ABBREVIATIONS, SYMBOLS, SPECIALIZED NOMENCLATURE

UTeM	-	Universiti Teknikal Malaysia Melaka
TPMS	-	Tyre Pressure Monitoring System
RTPMS	-	Remote Tyre Pressure Monitoring System
ABS	-	Anti-Lock Braking System
PSM	-	Projek Sarjana Muda
CST	-	Continental Sime Tyre
P	-	The pressure
F	-	The normal force
A	-	The area.
F_{tire}	-	Tire force, N,
M	-	Mass supported by tire, kg,
g	-	Acceleration of gravity, m/s2,
β	-	Incline angle (rad)
m	-	Vehicle mass (kg)
A	-	Effective frontal vehicle cross-sectional area (m^2)
h	-	Height of vehicle CG above the ground (m)
a, b	-	Distance of front and rear axles, respectively, from the vertical projection point of vehicle CG onto the axle-ground plane (m)
V_x	-	Longitudinal vehicle velocity (m/s)
F_{xf}, F_{xr}	-	Longitudinal forces on the vehicle at the front and rear wheel ground contact points, respectively (N)
F_{zf}, F_{zr}	-	Vertical load forces on the vehicle at the front and rear ground contact points, respectively (N)
C_d	-	Aerodynamic drag coefficient (N·s2/kg·m)

CHAPTER 1
INTRODUCTION

1.1 Introduction

Tyre is one of the most important parts of a vehicle. It enables vehicle performance by providing a medium for traction, braking, steering and load support. It also has a massive contribution towards providing a comfortable ride quality in a vehicle. Tyres, which are inflated with air, will provide a flexible cushion between the vehicle and the road that smoothes out shock in a bumpy ride situation. However, an appropriate amount of air or tyre inflation is required in order for the tyre to be well functioned.

Tyres are also one of the key factors affecting a vehicle handling and overall safety since it is the only part of a vehicle that physically touches the ground. Proper tyre inflation and maintenance are very important in extending tyre life, increasing fuel efficiency and improve vehicle safety. Under-inflated tyre will have a reduced contact path during a ride and this could lead to grip reduction and quicker tire wear. It will also adversely affecting handling of vehicles and stopping distance. On the other side, over inflated tyre provide an improvement in steering response and cornering stability up to a point. However, the tyre is easily damaged when running over pot holes on the road. Besides that the tyre cannot isolate road irregularities well and causing a harsh ride. Therefore a proper amount of tyre inflation is a key factor in providing a safety and comfortable ride.

Nowadays, plenty of pressure control system is being developed to control and monitor the vehicle tyre pressure. These technologies are developed to provide an

easy and safety feature in a vehicle that could help alerted the driver about the tyre pressure condition. However there are lots of factors that are need to be considered in determining the tyre pressure. The factors are divided into two categories which are internal factor and external factor. The internal factors that are calculated in determining the tyre pressure are vehicle weight and velocity, tyre types, specification and temperature. The external factors in determining the tyre pressure and their effect towards the tyre pressure will be studied and analyzed in this thesis before being simulated using MATLAB Simulink.

1.2 Problem Statement

Proper tyre inflation is required for a comfort and safety ride. The tyre inflation or the tyre pressure must be at an optimum level and should be maintained in order for the vehicle to be driven smoothly and safely in any road condition. Currently, lots of tyre pressure control systems are being developed. Most are designed to help the driver to monitor their vehicle tyre pressure in an easiest way. However, lots of aspects are needed to be considered in order to achieve the perfect control system for vehicle tyre pressure. This project is conducted to study, analyze and simulate the effect of external agent in the control of vehicle tyre pressure. The first part of this project is to determine the external agents that will be considered. Then, the external agent will be analyzed to determine their effect towards the tyre pressure.

1.3 Objectives

1) To identify the external agents that have effect in the control of vehicle tyre pressure
2) To analyze and evaluate the effects of those external agents towards the vehicle tyre pressure.
3) To design and simulate the tyre pressure control system that will visualize the effect of external agent towards the tyre pressure.

1.4 Scopes

Besides being the guidance to the author in completing the thesis, the project scopes are designed to inform the reader about the main focus and areas covered in the thesis. The scopes of this thesis are:

1) To identify and collect data regarding the effect of external agent towards the vehicle tyre pressure.
2) To study the Simulink block set, components and functions for utilization in the simulation
3) To troubleshoot and redesign existence simulation model with inclusion of the effect of the external agent.

1.5 Benefits

1) Improvise the current vehicle tyre pressure control system in order to ensure the safety of vehicle's users.
2) The conducted study could be used as a guidance or reference by vehicle's tyre manufacturer to produce tyre with better quality.

CHAPTER 2
LITERATURE REVIEW

2.1 Introduction

2.2 Tyre

Tyres are pneumatic enclosures used to protect and enhance the effect of wheels. Pneumatic tyres are made of a flexible elastomer material such as rubber with reinforcing materials such as fabric and wire. The pneumatic tyre was made in an effort to prevent shocks while riding on the rough roads of the time. However, the pneumatic tyre also has a more important effect of vastly reducing rolling resistance compared to a solid tyre. Because the internal air pressure acts in all directions, a pneumatic tyre is able to "absorb" lumps and bumps in the road as it rolls over them without experiencing a reaction force opposite to the direction of travel, as is the case with a solid (or foam-filled) tyre. The difference between the rolling resistance of a pneumatic and solid tyre is easily felt when propelling wheelchairs or baby buggies fitted with either type.

2.2.1 Functions of tyre:

a) Supporting the weight of the vehicle and its contents.
b) Absorbing shock and vibrations from the road.
c) Transmitting engine power to traction and brake forces.
d) Changing and maintaining the direction of travel.
e) Transmit the driver's intention and the vehicle power

f) Withstand and transmit gear forces

2.2.2 The tyre contact path

Despite a cars size, the only part of the vehicle in contact with the road is tyres. Each tyre contact area with the road is only the size of a normal postcard. Safety in acceleration, braking, steering and cornering all depend on this relatively small area of road contact. Therefore, it becomes more obvious that the care and maintenance of the tyres as well as the recommended inflation pressure have such an important impact upon a driver's safety, the environment and the cost of motoring. It is also important to ensure that the tyres fitted to the car are correctly selected and fitted by a trained professional.

2.2.2.1Friction.

The classical laws of friction as often taught to undergraduates can be summarized as [1]:

a) Friction is a property of two contacting surfaces. It does not make sense to discuss friction as if it were a material property.
b) Frictional force is linearly proportional to normal force and can be defined using a coefficient of friction.
c) The coefficient of friction is independent of contact area between the two surfaces.
d) The static coefficient of friction is greater than the kinetic coefficient of friction.
e) The coefficient of friction is independent of sliding speed.

A detailed treatment of this subject with regard to tyres is given by [2], where it is shown that the above laws are flawed, or limited in certain conditions such as high tyre pressures.

2.2.2.2Pressure distribution in the tyre contact path.

In order to understand the manner by which force forces and moments are generated in the contact path of a rolling tyre, an initial appreciation of the stresses acting on an element of tread rubber in the contact path is required. Each element will be subject to a normal pressure and a shear stress acting in the road surface [1].

The pressure distribution depends on tyre load and whether the tyre is stationary, rolling, driven or braked. The pressure distribution is not uniform and will vary along and across the contact path. Generally, the pressure rises steeply at the front and rear of the contact path to a value that is approximately equal to the tyre inflation pressure. Overinflation causes an area of high pressure in the centre of the contact path while underinflation leads to an area of reduced pressure in the centre of the contact path.

2.2.3 Tyre's Durability

Durability of a tyre has a direct effect upon safety. Running a tyre at low air pressure leads to heat build up and increase the risk of a tyre failing. Below, it can be seen that low tyre pressure has effects on the dynamics and durability of a tyre.

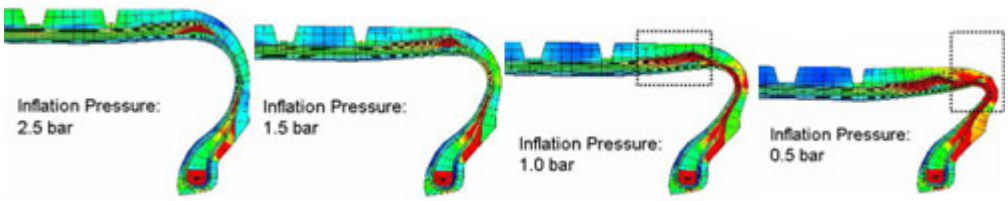

Figure 2.1: Effect of tyre inflation towards the tyre structure.

The red areas of the diagram above indicate the concentration of heat and friction build up. So as you can see, the lower the pressure, the more stress the tyre is under and the more likely it is to fail

2.2.4 Tyre Structure

Tyres are required to satisfy conflicting requirements. They need to be flexible so they can absorb road irregularities but stiff enough to generate cornering forces and maintain straight-line motion with an unchanging rolling radius. A tyre's internal pressure dictates a curved cross section, but the contact path must deform under load to give a flat area of contact on a road surface [3]

The carcass of the tyre is made up of a number of layers of flexible cords of high modulus of elasticity encased in a matrix of low modulus rubber compounds. The geometric disposition of the layers of rubber coated cords, particularly their directions, plays a significant role in the behaviour of the tyre. Tyres are commonly bias-ply or radial ply [4].

In bias-ply tyres, the cords in the carcass have an angle of approximately 40 degrees with respect to the circumference. The cords in adjacent plies run in opposite directions. A bias-ply tyre usually has 2 or more plies. The radial-ply tyre is a belted tyre and has one or more belts, in addition to plies. A belt is a steel mesh placed between the body and the tread. Each belt adds an additional layer in the tread area but leaves the sidewall area untouched. Besides the belt, a radial tyre also has plies just like the bias-ply tyre, but the cords in these plies are made of a softer material like polyester instead of nylon. The cords in the plies run perpendicular to the circumference of the tyre. On the side walls of the tyre, the direction of these cords is radial and hence the name "radial" tyres.

The use of radial ply tyres has now become more dominant for passenger cars and trucks. The radial ply tyre has low sidewall stiffness and provides a smoother ride. The contact path is also larger and more stable with radial tyres, hence providing better handling. The power dissipation of the radial ply tyre could be as low as 60% of that of the bias-ply tyre under similar conditions and the life of the radial-ply tyre could be as long as twice that of the equivalent bias-ply tyre [4].

2.3 Tyre Pressure

2.3.1 Tyre Pressure Check

The correct tyre pressure is always an important factor both in the safety and longevity of tyres. The check should be conducted when the tyre is “cold” because pressure increase through the heat generated during vehicle running. Tyres are considered to be cold when they have not been run for at least one hour or have only been run at low speed for not more than two or three kilometers.

Pressures should be checked regularly using a proprietary pressure gauge. A drop in pressure could be due to:

a) Air leakage through the wheel, bead seal or valve.
b) A fall in temperature
c) Small penetrations which, in tubeless tyres do not cause an immediate deflation but may, over a long period cause the tyre to lose pressure.
d) Natural diffusion of the air through the components of the tyre.

2.3.2 Inflation

Inflation pressure is an extremely important factor that has crucial effect on driving performances, mileage and fuel consumption. It also has some effect on tyre life, highway safety, ride quality and the longevity of the car. The correct inflation pressure value is given by the vehicle manufacturer and can be found in the vehicle log book and on some vehicles on the petrol cap or door inside pillar. Usually, the original tyres sizes and inflation pressures (including the spare) are listed on a vehicle placard which can be located on:

a) The driver-side door or door jamb
b) Glove box or counsel door