

TRACTION BEHAVIOUR ANALYSIS ON
AGED RUBBER USING LAB-SCALE
ENVIRONMENT SIMULATED SYSTEM

AMIRUL HAKIM BIN SUFIAN

MASTER OF SCIENCE

UNIVERSITI MALAYSIA PAHANG



SUPERVISOR'S DECLARATION

We hereby declare that we have checked this thesis and in our opinion, this thesis is adequate in terms of scope and quality for the award of Master of Science.

(Supervisor's Signature)

Full Name : DR. AHMAD SHAHIR BIN JAMALUDIN

Position : SENIOR LECTURER

Date :

A handwritten signature in black ink, appearing to read 'Mohd Nizar', is written over a horizontal line.

(Co-Supervisor's Signature)

Full Name : DR. MOHD NIZAR BIN MHD RAZALI

Position : SENIOR LECTURER

Date :



STUDENT'S DECLARATION

I hereby declare that the work in this thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at Universiti Malaysia Pahang or any other institutions.

(Student's Signature)

Full Name : AMIRUL HAKIM BIN SUFIAN

ID Number : MFA18001

Date :

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AMIRUL HAKIM BIN SUFIAN

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ABSTRAK

Penuaan tayar adalah faktor penting yang mempengaruhi prestasi dan keselamatan kenderaan di jalan raya. Infrastruktur kajian dan analisis penuaan tayar kebanyakannya adalah besar, kompleks, dan mahal, yang menghadkan pemahaman tentang penuaan tayar dan kesannya terhadap prestasi tayar tersebut. Sebuah peranti eksperimen yang praktikal dan cekap diperlukan untuk menimba pengetahuan menyeluruh mengenai fenomena penuaan tayar ini. Oleh kerana pengguna jalanraya berisiko mengalami kegagalan tayar disebabkan oleh factor umur tayar atau kerosakan, pemahaman tinggi terhadap proses penuaan getah dan hubungannya dengan prestasi tayar adalah amat penting. Objektif kajian ini adalah untuk menyiasat proses penuaan getah di bawah keadaan persekitaran yang disimulasikan dalam persediaan berskala makmal serta menganalisis sifat daya tarikan bahan getah yang telah menua dan menubuhkan hubungan antara sifat penuaan dan prestasi daya tarikan. Dalam kajian ini, persediaan berskala makmal, termasuk kebuk penuaan dan alat pengujian daya tarikan, direka bagi menjalankan eksperimen pada spesimen getah asli. Kajian ini melibatkan pengukuran perubahan sifat mekanikal getah asli dan perbandingan ciri-ciri sentuhan elastomer getah seiring penuaannya. Dalam fasa pertama kajian, kekerasan getah meningkat sebanyak 20% apabila suhu dan masa penuaan meningkat sehingga 30 hari dapat diperhatikan. Fenomena ini dipercayai disebabkan oleh proses pengoksidaan dan pengerasan getah asli melalui penuaan haba. Tambahan lagi, ujian regangan menunjukkan penurunan kekuatan sehingga berbaki 20%. Dalam fasa kedua kajian, data ujian daya tarikan menunjukkan penurunan kecekapan daya tarikan purata berbaki sebanyak 20% dengan penuaan getah sehingga 60 hari. Fenomena ini berkemungkinan disebabkan oleh proses degradasi yang dipercepat serta kerosakan kumulatif. Selain itu, hasil ujian geseran menunjukkan penurunan daya tarikan purata dan pekali geseran seiring penuaannya berbaki 20%. Kajian ini menunjukkan bahawa, penuaan getah memberi kesan negatif terhadap tingkah laku daya tarikan dan geseran, yang memberi kesan kepada prestasi getah atau elastomer, sama sekali memberi kesan kepada prestasi keselamatan tayar. Dengan kefahaman terhadap fenomena ini, pembangunan strategi untuk mengurangkan kesan negatif penuaan terhadap prestasi getah, elastomer atau tayar dalam pelbagai aplikasi dapat dijalankan di masa hadapan.

ABSTRACT

Tire aging is a critical factor that affects the performance and safety of vehicles on the road. Existing tire aging facilities are often large, complex, and expensive, limiting the understanding of tire aging and its impact on performance. A compact and efficient experimental device is needed to provide comprehensive knowledge about tire aging and its effects on tire performance. Road users are at risk of tire failure due to aging or damage. Thus, a better understanding of the rubber aging process and its relation to tire performance is crucial for developing effective strategies to prolong tire life and ensure road safety. The objectives of the study are to investigate rubber aging process under simulated environmental conditions in a lab-scale setup and to analyze traction behaviour of aged rubber materials and establish the relationship between aging and traction performance. In the study, a lab-scale setup, including an aging chamber and a traction tester, was designed to conduct experiments on rubber specimens. The study involved measuring the change in mechanical properties of tire rubber and comparing the contact characteristics of the tire rubber elastomer as it aged. In the first phase of the study, it is also observed that rubber hardness increased up to 20% as temperature and aging time increased up to 30 days. It is assumed that the phenomenon is due to oxidation and hardening of natural rubber through thermal aging. Additionally, the tensile test showed a decrease in stress as slow as 20% and elongation at break for rubber specimens with aging, as well as strain and stress at fracture decreased with increased aging duration and temperature. In the second phase of the study, traction test data showed a decline in average traction efficiency as lower as 20% as the rubber aged, possibly due to accelerated degradation processes, cumulative damage, or threshold behaviour. Furthermore, friction test results showed a decrease in average pulling force and friction coefficient as the rubber aged as slow as 20%. As summary, rubber aging negatively affects traction and frictional behaviour, impacting the performance and safety of tires. Understanding these relationships can help develop strategies to mitigate the negative impact of aging on rubber performance in various applications. In the suggested in future that, more advanced lab-scale setups could be developed for a better understanding of the aging process and its effects on tire performance, as well as exploring new materials or technologies to prolong tire life and enhance road safety are other areas of interest.

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LIST OF SYMBOLS

t_d	Desired age
T_1	Elevated temperature
T_0	Ambient temperature
Q_{10}	Material temperature coefficient
t_a	Accelerated ageing time
Q	Heat produce
m	Mass of air inside the chamber
c	Specific heat capacity
ΔT	Change of temperature
H	Heat
V	Voltage
I	Current
R	Resistance
h	Convection heat transfer
A	Cross sectional area of fin
F	Force

N	Newton
mm	Millimeter
°C	Degree Celsius
V	Volt

LIST OF ABBREVIATIONS

ASTM	American Society for Testing and Materials
BR	Polybutadiene
-CH ₃	Benzene
DMA	Dynamic Mechanical Analyzer
HDMI	High-Definition Multimedia Interface
IRHD	International Rubber Hardness Degrees
ISO	International Organization for Standardization
MCB	Miniature Circuit Breaker
MIROS	Malaysian Institute of Road Safety Research
MMD	Malaysian Metrology Department
NBR	Nitrile butadiene rubber
NTC	Negative Temperature Coefficient
PTC	Positive Temperature Coefficient
RPM	Revolution per Minute
SBS	Poly(styrene-butadiene-styrene)
SR	Silicone Rubber
TPT	Tire Pavement Tester
UTM	Universal Testing Machine
VT-LWST	Variable Temperature Load Wheel Slip Tester
UV	Ultraviolet

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