PREDICTION OF THE SHELF LIFE OF PNEUMATIC TYRES MADE WITH DIFFERENT COMPOUNDS

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Declaration

I hereby declare that this project was conducted by me at the Samson Rubber Industries (Pvt) Limited, DSI- Samson Group, under the supervision of Dr. Sudantha Liyanage, Senior Lecturer, Department of Chemistry, University of Sri Jayewardanepura, Sri Lanka. I also certify that this thesis does not include, without acknowledgement, any material previously published by any other person and to the best of my knowledge, this research has not been conducted by any other person or an institution.

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LIST OF ABBREVIATIONS

ASTM	-American Society for Testing Materials
BSI	-British Standard Institute.
BR	-Butadiene Rubber
Ca	-Circa or approximately
CB-A	-Chain Breaking Acceptor
CB-D	-Chain Breaking Donor
CTAB	-Cetyl Trimethyl Ammonium Bromide
Co	-Cobalt
CR	-Polychloroprene Rubber (Neoprene)
DBP	-Di Butyl Phthalate
DIN	-Deutisches Institut fur Normung (German test Standards)
EPDM	-Ethylene Propylene Diene monomer
E	-Activation Energy.
Fig.	-Figure
HAF	-High Abrasion Furnace
HAF – HS	-High Abrasion Furnace – High Structure
ISO	-International Organization for Standardization
IRHD	-International Rubber Hardness Degree
IPPD	-N - isopropyl-N' –phenyl-p-phenylenediamine
Kg	-Kilogram
Li	-Lithium
MD	-Metal ion deactivators

MPa	-Mega Pascal
Nd	-Neodymium.
Ni	-Nickel
No.	-Number
NR	-Natural Rubber
N_2	-Nitrogen gas
ODR	-Oscillation Die Rheometor.
PPD	-Para-phenylenediamine
6 PPD	-N –(1,3 –Dimethylbutyl) –N'- phenyl –p – phenylenediamine
Q	-Quencher
RSS	-Ribbed Smocked Sheet
RHC	-Rubber Hydro Carbon
R	-Gas constant
S.G	-Specific Gravity
SBR	-Styrene Butadiene Rubber
TMQ	-2, 2, 4-Trimethyl-1, 2-dihydroquinoline, polymerized
Ti	-Titanium
TS, T/S	-Tensile Strength.
Tg	-Glass Transition Temperature
WLF	-Williams Landel Ferry

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ABSTRACT

An unused old tyre may appear to have similar properties to a newly manufactured tyre but may fail during the service, causing a heavy damage. Therefore it has become very important to know the shelf life of a tyre.

Tyre is a composite, where steel wires and fabric bonded by different rubber compounds which undergo a chemical reaction during the course of tyre production. Vulcanization, the chemical reaction between the diene rubber and sulphur occurs at high temperature giving desired physical properties, at the same time commencing the ageing.

The ageing or the deterioration of polymers can be slowed down by using anti degradants. Uses of polymer blends also help reduce the degradation as well as to improve the properties. Proper blending, taking note of concepts of phase separations, interfacial bonding, filler incorporation etc. is a very important parameter.

Among many approaches for the prediction of long term behaviour of polymers, the Williams Landel Ferry (WLF) and Arrhenius methods are very popular. The WLF approach is appropriate where the viscoelastic phenomena are predominant and Arrhenius approach is most widely used when physico-chemical mechanisms are dominant.

The latter was used in this study on the assumption of that tyres undergo only thermal-oxidation in the shelf. The simulation of ageing was done by accelerated artificial ageing of dumbbell samples in a cabinet oven at 80°C, 85°C, 90°C and 95°C until the tensile strength drop down to 50% of the original value which is the end of life criterion, referring to ISO 11346:1997 "Rubber, vulcanized or thermoplastic – Estimation of life time and the maximum temperature of use from an Arrhenius plot". In this study shelf life of three tread compounds, motor cycle tyre, bicycle tyre and economical bicycle tyre were studied.Number one designed for motor cycle tyres to have superior performance has given a shelf life of 10.7 years at 40°C which is the assumed temperature of storage. The compound number two a premium quality bicycle tread formulation has given 8.5 years and the compound number three an economical version bicycle tread formula has given 3.3 years. The maximum temperature of storage was also determined as per ISO 11346:1997. This study clearly shows that there is a correlation between the composition of the compound formulations and the shelf life. Also the maximum temperature of storage is correlated with the composition.

CHAPTER 1 - INTRODUCTION

1.1 Background motivation.

Even if an unused old tyre may appear to have similar properties to a newly manufactured tyre, once the vehicle is moving at high speed , (i.e. on a highway) the tread could peel off or the tyre could burst, leading to severe lose to control and perhaps a roll over. Therefore it has become very important to know the shelf life of a tyre.

Tyre is a composite, where steel wire and fabric are bonded by different rubber compounds. Rubber compounds are made out of Natural Rubber; cis poly isoprene (NR), Styrene Butadiene Rubber (SBR), Butadiene Rubber (BR), Ethylene Propylene Diene Monomer (EPDM), blended or individually. Sulphur is used as cross linking agent that is to link chemically the elastomers together to make a network, which leads to the thermoplastic elastomer to thermo set. Carbon black or silica is mixed in fine particle form with elastomer to harden and strengthen the compound[1,2]. Some basic organic chemicals accelerate the cross linking reaction, Zinc oxide and stearic acid increase the number of cross links at particular reaction temperature, called activators. Performance life as well as the shelf life is increased by antioxidant[3], anti ozonants and waxes[4]. Processing aids are used to optimize the mixing of these additives with base elastomers and improve the processability[5].

The tyre is shaped at high temperature and under pressure. The compound flow into the mould, the fabric and steel wires are positioned as the tyre changes to toroidal shape. Compounds start the chemical reaction at around 150°C, which is the mould

temperature. Elastomer molecules link by sulphur concomitantly thermo oxidation session starts.

After attaining the optimum physical properties the tyre is mounted on a rim and permitted to cool while inflated to reduce internal stresses called post curing. Even at room temperature, the cross linking reaction as well as the rubber molecular secession started at curing temperature i.e. at 150°C is not ceased, which leads to physico - chemical changes in the tyre where ageing the tyre in shelf starts.

1.2 Aims & objectives:

- Establishing an accelerated ageing technique to simulate the shelf life.
- Identify a measuring technique for ageing.
- Identify a scientific methodology for quantitative shelf life prediction.
- Correlation between accelerated ageing and shelf life.

1.3 History of tyre:

Tyres are ring shaped parts, either pneumatic or solid that are fixed around wheels to protect them and enhance their functions. Pneumatic tyres are used on many types of vehicles, such as bicycles, motorcycles, cars, trucks, earth movers and aircrafts. Tyres enable better vehicle performance by providing traction, braking, steering and load support. Tyres form flexible cushion between the vehicle and the road, smooth out shocks and makes for a comfortable ride. The earliest tyres were bands of iron (later steel), placed on wooden wheels, used on carts and wagons.

The tension of the metal band served the purpose of holding or tying the wooden spokes of the wheel together, hence the term "tyre" continued to be used for the outer band even when it no longer served the purpose of tying the spokes together. The first practical pneumatic tyre was made by John Boid Dunlop, in 1887 for his son's bicycle.

1.4 Pneumatic tyre[6]:

A tyre is an annular, toroidal shaped inflatable envelop, made of rubber which is reinforced with cord, enclosing coiled wire bead rings. It is fitted to a metallic ring which is secured to the vehicle.

1.4.1 Pneumatic tyre components:

There are three main parts; casing, tread and bead.

1.4.1.1 Casing:

The casing, which is made of layers of textile cord fabric or steel cord surrounded by rubber compounds, provides the strength and the dimension stability of the tyre. The following components make up a typical casing.

a. PLIES:

These are layers of textile or steel cord fabric, coated with rubber compounds which are cut to the required dimensions and bias angle. They are locked around the bead wire coils. The textile may be cotton, rayon or nylon. Steel, glass fiber and polyester are also used. The use of cotton is almost abandoned due to its inferior properties.