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FACULTY OF ENGINEERING
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TYRE TREAD TEMPERATURE UNDER DIFFERENT WORKING CONDITIONS

A Thesis submitted for the Partial Fulfilment
of the Degree of Master of Science in
Mechanical Engineering

27813

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CAIRO, JULY, 1987

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STATEMENT

This dissertation is submitted to Ain Shams University for the degree of Master of Science in Mechanical Engineering.

The work included in this thesis was carried out by the auther in the Department of Design & Production Engineering, Ain Shams University, from November 1980 to July 1987.

No part of this thesis has been submitted for a degree or a qualification at any other University or Institution.

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CONTENTS

Page

ACKNOWLEDGEMENT

The author wishes to express his deep gratitude to his supervisores Dr.T.A.Nosseir and Dr.A.M.Hussein for their guidance and encouragement during this work.

The author would like to thank the former directors of Armed Forces Technical Research Center Maj. Gen. Dr. Mohammed H. Azmy and Maj. Gen. Dr. Yousry A. Khattab for their great encouragement and help.

The author would like to thank Lt. Col. Dr. Safwat Zahran for his great help during the work concerning the computer.

The author also wishes to acknowledge all the staff of the Armed Forces Technical Research Center Automotive Laboratory and all those who were helpful in producing the thesis in its present form.

GLOSSARY

These glossary is taken from 1982 . SAE HANDBOOK , pp29.01

Bias Ply Tyre

Pneumatic tyre in which ply cords extending to the beads, are laid at alternate angles less than 90 degrees to the centerline of the tread. The angle between two consecutive tread fibers is called the crown angle .

Tread

Portion of tyre which comes in contact with terrain .

Side Wall

Portion of tyre between tread and bead .

Bead

Part of the tyre which is shaped to fit the rim , made of high tensile steel wires , wrapped and reinforced by the plies .

Carcass

Tyre structure , except tread and sidewall rubber .

Ply

Layer of rubber - coated parallel cords forming tyre body.

Cord

Textile , steel wire strands , and the like , forming the plies in the tyre .

Ply Rating

Index of tyre strength , does not necessarily represent the actual number of plies in the tyre . It is used to relate a given size tyre with its load and inflation limits .

SUMMARY

Due to the existance of hysteresis in a loaded rolling tyre , an appreciable heat is generated. The generated heat dissipates with different rates of conductivity for a certain type according to many parameters e.g. speed, inflation pressure, depth of tread, road condition and surface material.

In this work, the effect of some parameters " speed , inflation pressure and rubber depth " on the temperature distribution within the tyre tread has been investigated. Experimental work was carried out to reach the steady state under definite operating conditions for the tested tyre, in the tyre tread section, before measuring the temperature and its distribution.

The theoretical work out-lined a mathematical relationship between the temperature and these parameters for a definite operating conditions as well as the temperature distribution across the tyre tread .

The tyre shoulder is found to be the hottest region, and the tyre tread temperature distribution at a certain depth is a polynomial relation of third order between

temperature and positions from the right shoulder to the left one .

The equation of the temperature as a function of the speed, inflation pressure or depth realizes the general solution of the heat conduction equation.

In-general the temperature of the tyre increases with increase in speed, depth while decreases with increase of inflation pressure. The rate of variation differs according to test conditions .

The test procedure outline can be adopted as a code for determination of the most favorite working condition for a certain type. Comparative evaluation of tyre durability can also be judged by this test code. It is a quick and economic way with no need for the todays practice which lasts for more than 45 hours for one tyre .

Note:

Right and left shoulders are to be in the site of the vehicle inner axis in the direction of motion .

NOTATION

Please, see contex for precise meaning of the symbols.

a_i	$i = 0,1,2,...$	Constants of temperature speed equation	-
c		Specific heat	kj/kg C^o
c_j	$j = 0,1,2,...$	Constants of temperature inflation pressure equ.	-
d_k	$k = 0,1,2,...$	Constants of temperature depth equation	-
k		Thermal conductivity	W/m C^o
m		Number of data points	-
n		Order of the polynomial	-
p		Inflation pressure	psi
P_z		Vertical load	kp
q		Energy generated per unit vol.	kj/m^3
$\triangle t$		Tyre deflection under load	mm
t		Depth 'inside tread section'	mm
T		Temperature	^oC
V		Equivalent vehicle speed	km/h
X		Operating variable	-
α		Thermal diffusivity	m^2/s
ρ		Density	kg/m^3
τ		Time	s
[ ]		Square bracket contains base level values	

Other symbols are considered and will be defined in due course.

INTRODUCTION

Generally, the function of the tyres is to form a cushion between the road and the vehicle wheels. So, they absorb the shocks resulting from holes and bumps in the road. Also they provide the good adhesion between the wheels and the road during acceleration and deceleration of the vehicle. Tyre casings are made of layers of cord impregenated with rubber. The rubber of the sidewalls and the tread are constructed over the cord. The layers of cord called the plies. The plies tend to move against each other when the tyre is in function. This produces heat particularly at high speed.

Heat build-up is so important to tyre durability that new measurement methods are continually being sought by the rubber tyre manufactures. Many of the methods used in the past have involved electrical transducers, either embeded in the running tyre, or inserted in the stationary tyre after the desired warm-up.[1*]

Conant, et. al.[2] defined the surface temperature of running tyres by using an infra-red line scanning system. Surface temperature of tyres was measured under operating conditions by changes in tyre speed, inflation pressure and load. It was found that these effects are different at different radii positions on a given tyre and quite

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* References are given at the end.

dependent on the tyre construction " bias, belted bias and radial " of the same size.

The transducers most often used have been thermocouples, which can be small enough to minimize the effects of both heat generation and conductive cooling at the test site. Thermocouples or thermistors for active service may be cemented into holes drilled into the completed tyre,[3] they may be placed in the green tyre during the building process.

Limitations on transducers of the tyre, mention before, include the destructive nature of the test and the single point response. At least two nondestructive averaging methods have been used by the engineers, contained air temperature measurement,[4] and nonscanning infra-red sensors.[5] The former is related to the rate of energy absorption of the entire tyre and the latter to the average surface temperature of the tyre annulus in the field of vision.

Each of these is an important index of tyre performance but neither is sufficiently specific for tyre tread temperature distribution with respect to depth specially for tyre development, testing control and vehicle rolling resistance.

Thus the purpose of this work is :

1- To establish an appropriate method to measure the tyre temperature.

2- To find the tyre tread temperature distribution with respect to depth under differnet operating conditions.