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TYRE PROFILE ARITHMETIC AND PERFORMANCE PARAMETER: A REVIEW OF VEHICLE USERS AND VULCANIZERS' COGNIZANCE ON CAR TYRE MAINTENANCE TO CURB ROAD ACCIDENTS

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Abstract

Ageing car tyres are a hidden hazard and recipe for road accidents. Many vehicle users and their cohorts seem unconcerned and ignorant about tyre profile and its implications on human lives and livelihood. This study reviewed car users' and vulcanizers' comprehension of basic arithmetic of vehicle tyre profile to instigate best practices as well as instil proper maintenance culture. Out of 307 participants, purposive and convenient sampling were employed to select 292 vehicle users and a snowball to contact 15 vulcanizers. Results after a short interview analysis revealed that car users are aware of tyre inflation pressure and could identify the rim diameter of car tyres. Meanwhile, a significant number of users couldn't tell where to locate their vehicle tyre specification details on their cars and were also unable to interpret tyre profiles including; tyre life cycle, tyre blend, tyre speed rating and load index. Although the majority of vehicle users carried spare tyres, most of them do not check the conditions of their spare tyres until they are in need. Responses from vulcanizers revealed that most vehicle users do not bother about tyre expiry dates but rather prefer tyre fixing to tyre replacements. It is recommended that the Leaders of Transport Unions of commercial vehicles need to ensure the proper load weight of vehicles before setting off from their terminals. Drivers and Vehicle License Authority (DVLA) needs to ensure healthy tyre condition before issuing roadworthy certificates. National Road Safety Authority (NRSA) must maximize sensitization campaigns towards proper tyre maintenance practices to reduce tyre failure accidents.

Keywords: Tyre profile, vulcanizers, road accidents, pneumatic tyres

I. Introduction

Recent reports from the Motor Traffic Transport Unit (MTTU) of the Ghana Police Service suggest that about 8 deaths and 43 injuries are recorded daily on Ghana's roads. This has become an issue of major public health challenges that need public education, road engineering and law enforcement. The poor nature of roads and driver attitude are usually reported as the main cause of road accidents. Meanwhile prosecuting and arresting drivers due to behavioral influences towards road crash risk is not enough but rather ensuring proper education on maintenance practices of vehicles makes vehicle users stay alert.

The invention of pneumatic tyres by John Boyd Dunlop in the late 1880s has played an increasingly important role in vehicle performance. Car tyres which is the main intermediary between vehicles and roads serve as the forces behind providing vehicle changing direction, vehicle dimensional stability, vehicle brake tracking and weight carrying of the vehicle. The rolling resistance which is the repeated flexing of car tyres is mostly affected by the nature of roads. This has led to several innovations including the introduction of tubeless tyres because every tyre type causes different degrees of rolling resistance (Virkar et al, 2013). Conditions including the rolling resistance characteristics, tyre temperature, tyre traction, and tyre wear also affect vehicle fuel economy.

The vulcanization of pneumatic tyres requires certain proper conditions to avoid tyre deformity based on either low or high air inflation. Knowledge on the importance of proper tyre condition and maintenance has a critical effect on fuel economy to foster vehicles' safe operation and performance. The big question is; do vehicle users and tyre operators know and understand these important determinants of rolling resistance including tyre profile and tyre design parameters?

II. Basics of Tyre Profile Arithmetic and Performance Parameters

A very important part of every automobile vehicle is the tyre which grants the capacity for movement. When a defective tyre is fixed in a car, regardless of the efficiency of all other parts the vehicle will be subject to a potential blowout or damage which may cause injury or harm to its users and other road users. Tyre defects can easily be identified by ensuring the tyre profile and understanding the basic arithmetic of the specification details indicated by the manufacturer.

Meanwhile, most vehicle users (literates and illiterates) are unable to interpret the basic arithmetic on their tyre profile including determining the expiry date of tyres they buy to fix in their cars. The majority of car tyres might have reached their expiry dates on market shelves including spare tyres of new vehicles without the notice of both sellers and buyers. An expired vehicle tyre might seem healthy to the eyes but the rubber might be weak to contain high or low inflation pressure. A car tyre that is either overfilled or underfilled with air might as well cause a blowout due to vehicle load. The ignorance or negligence of not ensuring the rudimentary meaning of the basic arithmetic of a car tyre profile may cause the loss of lives and livelihoods of road and vehicle users.

Tyre specifications

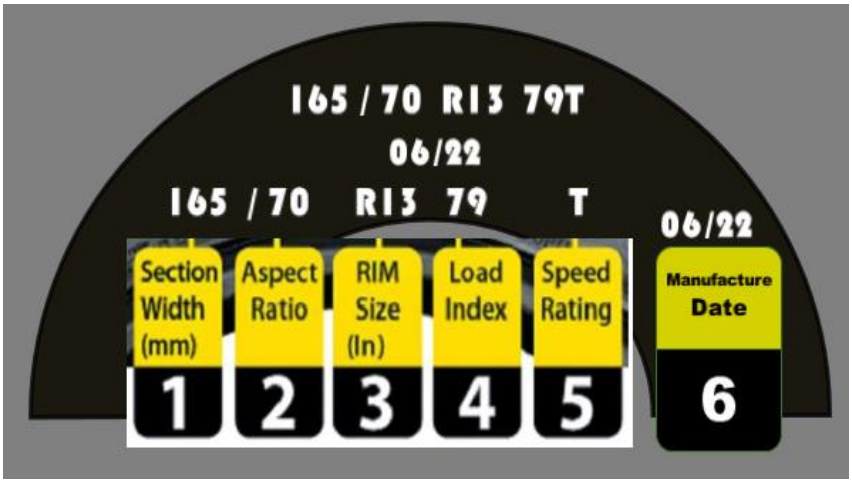

Fig 1. Sample Tyre Specification

According to Chen & Yen (2018) users only check their tyres when they perceive or notice an unusual performance of the tyre meanwhile they ignore or dedicate little concerns about the specification details which are usually shown on the sidewall of every tyre. From Fig1, a typical tyre with specification (165/70R13 79T; 06/22) is shown and details of the arithmetic numbers are explained below;

1. Section Width: the first value in this case 165 indicates the tyre width which is measured in millimetres (mm). The Section Width is obtained by measuring the breadth of the face of the tyre that touches the ground.
2. Aspect Ratio: this is simply the ratio of the tyre width compared to the height of the tyre (distance between the inner circumference and the outer circumference of the tyre). From the specifications in Fig 1, 70 indicates the aspect ratio in percentage. This means that 70% of the tyre height makes the tyre width.
3. Rim Diameter: this is the diameter in inches of the inner circle of the tyre. R13 indicates that the tyre has a Rim diameter of 13inches.
4. Load Index: this refers to the amount of weight in kilograms (Kg) each tyre is expected to carry. Therefore 79 indicates the weight/load index of this particular tyre. The weight of the load carried by the tyre is a determinant of the speed of the tyre. Details of the loading index as in the amount of weight in terms of kilograms (Kg) are shown in Table 1.0 below.

Table 1: Loading Index for Car Tyres (Garbrah, 2022)

Load Index	Load in Kg	Load Index	Load in Kg	Load Index	Load in Kg
62	265	84	500	106	950
63	272	85	515	107	975
64	280	86	530	108	1000
65	290	87	545	109	1030
66	300	88	560	110	1060
67	307	89	580	111	1090
68	315	90	600	112	1120
69	325	91	615	113	1150
70	335	92	630	114	1180
71	345	93	650	115	1215
72	355	94	670	116	1250
73	365	95	690	117	1285
74	375	96	710	118	1320
75	387	97	730	119	1360
76	400	98	750	120	1400
77	412	99	775	121	1450
78	425	100	800	122	1500
79	437	101	825	123	1550
80	450	102	850	124	1600
81	462	103	875	125	1650
82	475	104	900	126	1700
83	487	105	925		

A vehicle's weight forms part of the load weight index by exerting much force on the tyres depending on vehicle characteristics. According to Virkar (2013) vehicle characteristics that have substantial influences on weight include; nature of vehicle design material, seat design material, steering architecture, axle geometry and vehicle suspension.

5. Speed Rating: this is the rate of moving capacity for rapid motion of a tyre measured in kilometres per hour (Km/h). It is usually attached to the tyre weight or load index number with a letter. From Fig.1 the speed is denoted by the letter T. Details of tyre loading index as in speed symbol or letter and its interpreted speed ratings are expressed in Table 2. below.

Table 2. Speed Symbols and Ratings of Car Tyres (Garbrah, 2022)

Speed Symbol	Max Car Speed Capacity		Speed Symbol	Max Car Speed Capacity	
	Km/h	MPH		Km/h	MPH
L	120	75	**S**	180	113
M	130	81	**T**	190	118
N	140	87	**U**	200	125
P	150	95	**H**	210	130
Q	160	100	**V**	240	150
R	170	105	**W**	270	168
			Z	240+	150+

It is asserted that the rolling resistance of tyres is directly proportional to the speed of tyres and therefore the influence of speed becomes more important when inflation pressure combines with load weight (etyres, 2018). Considering the nature of the road and the style of driving, vehicle acceleration varies through speed modification causing stress, cracks and wear to tyre design material.

6. Manufacture Date/Tyre Expiry: the manufacturing date (indicated in week/year) of every tyre also determines the expiry date of the tyre. From Fig 1, **06/22** on the sidewall indicates the manufacturing date; meaning that the tyre was manufactured in the 6th week of the year 2022. According to Chen (2018), car tyres have a life span of 6 years and therefore expiry date can be determined 6 years from the date of manufacturing. Symptoms like tread mark limit less than 1.6mm indicates that those tyres are not safe and should not be used.

The majority of car users do not know and understand these codes indicated on vehicle tyres except for about 4% (Arkoh et al, 2018). This suggests that ageing and deformed tyres should be a major concern for prompt maintenance practice and replacement by vehicle users. Also when replacing aged and deformed tyres, it is recommended that matching tyres in terms of specifications be considered. For instance, the British Tyre Manufacturers' Association (2011) suggests that when mixing tyres, it is improper to fix fit radial axle and cross-piles to the rear and also it is not appropriate to mix tyres of significant wear across an axle (Arkoh et al, 2018;p.3). Therefore when considering the replacement of tyres the appropriate tyre mixing in terms of common characteristics for all four tyres should be ensured. This is because different tyre characteristics mixed for vehicles may undermine better tyre performance.

III. Performance Parameter

The inflated rubber structure of pneumatic tyres plays a very important role by providing vehicle performance towards a safe journey. As one of the most important components of vehicles, car tyres perform fundamental functions including; the ability and capacity to carry the load, providing cushion, transmitting driving, cornering force to assist operations of brake torque, providing stability for the vehicle to damp against

the surface of the road. Based on these functions, car tyres need to meet certain performance parameter standards about; tyre inflation pressure, tyre wear and tyre noise to acquire better rolling resistance (Virkar et al, 2013).
Virkar et al (2013) assert that tyre inflation pressure has implications on the elasticity of tyres and seasonal environmental factors like temperature and humidity affect both the tyre rubber and the ground. It may be argued that optimum tyre pressure may depend on ground surface characteristics especially high pressure inflated tyres may exert deep penetration into soft surfaces grounds but it is opined that most vehicle tyres are usually under-inflated (Abdul Wahab et al, 2017).

According to RoSPA (2018), the wear performance of car tyres depends on their ability to reach high mileages as well as satisfying a legal tread limit of 1.6mm or more on a tread indicator. When the tyre rolls and compresses the ground surfaces on rough roads, treads wear increases causing tyre/road noise. Usually, this is a result of the tread element losing contact and allowing the voids to expand making air forcing out of voids due to repetitive compression.

Abdul Khalid et al (2018) affirms that improper tyre maintenance in terms of tyre inflation pressure and tyre wear may result in tyre failure crashes. Despite all these facts which are readily available on car manuals and placards, many vehicle users' attitudes towards tyre maintenance knowledge and practices are questionable. And therefore poor knowledge on maintenance practices has led to a poor attitude towards tyre maintenance causing tyre failure related road crashes and accidents (Abdul Wahab et al, 2017).

IV. Research Methodology

This study employed a descriptive and cross-sectional survey design that collects information at just one point in time. Surveys serve the purposes of making descriptive and explanatory assertions about the population via inquiry (Creswell et al, 2011).

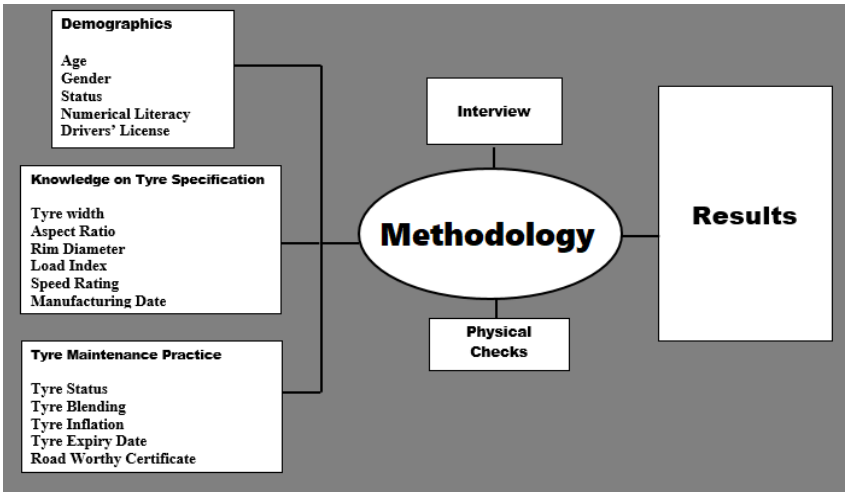

Fig 2. Methods Employed for the Study

V. Population

The study area was Mampong which is one of the 30 Districts in the Ashanti Region of Ghana and the capital of Mampong Municipality. According to the 2014 Population and Housing Census (PHC) conducted by the Ghana Statistical Service (GSS) Mampong is located within the longitudes $0^0$05" W and$1^0$30" W and latitudes $6^0$55" N and $7^0$30'N. Mampong has a population of 42,037 people (GSS; PHC, 2014).

VI. Sampling

307 respondents participated in the study including; licensed drivers of commercial vehicles and their attendants ("mates"), private car users and vulcanizers. Convenient and purposive sampling was employed for the selection of vehicle drivers at the various lorry and fuel stations and snowball was used to locate vulcanizers.

VII. Data Collection

A semi-structured questionnaire was used as a guide for the conduct of interviews. A pilot test was rolled out among members of the AAMUSTED university community to ensure that the questions and methods covered the necessary data expected to suit the objective of the study. The main data collection exercise happened at three main locations; commercial vehicle stations, fuel stations and vulcanizing shops. A descriptive statistical analysis of data collected was done using statistical packages for social sciences (SPSS).

VIII. Results

Table 3: Respondents' Demographic Background

Description	Category	Frequency (N)	Percentage (%)
Age	21 - 30	120	39.1
	31 – 40	113	36.8
	41 – 50	74	24.1
Gender	Male	222	72.3
	Female	85	27.7
Status	Commercial Driver/ Mate	200	65.1
	Private Car User	92	30.0
	Vulcanizer	15	4.9
Numerical Literate	Yes	298	97.1
	No	9	2.9
Drivers' License	Yes	286	98.0
	No	6	2.0

Table 3 reveals the demographic background of 307 respondents of which 222 are males and 85 females and their ages ranged from 21 to 50 with a mean age of 34years.

The respondents comprised of 65.1% commercial drivers, 30.0% private car users and 4.9% vulcanizers whereby 98% of the vehicle users have acquired driver's license.

Table 4: Respondents' Knowledge on Identification and Explanation of Tyre Specification

Description	Category	Frequency (N)	Percentage (%)
Tyre Width	Correct	30	9.8
	Incorrect	277	90.2
Aspect Ratio	Correct	7	2.3
	Incorrect	300	97.7
Rim Diameter	Correct	307	100
	Incorrect	0	0
Tyre Air Inflation Pressure	Correct	211	68.7
	Incorrect	96	31.3
Load Index	Correct	3	1.0
	Incorrect	304	99
Speed Rating	Correct	3	1.0
	Incorrect	304	99
Manufacturing/ Expiry Date	Correct	25	8.1
	Incorrect	282	91.9

Table 4 summarizes respondents' cognizance on identifying and explaining where possible tyre profile in their vehicle and or the picture in Fig 1. It was revealed that a higher percentage of respondents 100% and 68% could identify and explain their Rim Diameter and Tyre Inflation Pressure respectively. Less than 10% of respondents were able to identify and or explain tyre width, aspect ratio, load index, speed rating and manufacturing dates of tyres.

Table 5: Vulcanizers' Knowledge on Identification and Explanation of Tyre Specification

Description	Category	Frequency (N)	Percentage (%)
Tyre Width	Correct	11	73.3
	Incorrect	4	26.7
Aspect Ratio	Correct	7	46.7
	Incorrect	8	53.3
Rim Diameter	Correct	15	100.0
	Incorrect	0	0.0
Tyre Inflation	Correct	15	100.0
	Incorrect	0	0.0
Load Index	Correct	3	20.0
	Incorrect	12	80.0
Speed Rating	Correct	3	20.0
	Incorrect	12	80.0
Manufacturing/ Expiry Date	Correct	13	80.0
	Incorrect	2	20.0

Table 5 shows how vulcanizers who are tyre operators know tyre arithmetic parameters and whether they could identify and explain to their clients. Results showed that the few respondents who were able to identify tyre load index, speed rating and manufacturing dates were vulcanizers. It was also realized that only vulcanizers at fuel stations could identify and or explain tyre load index and speed rating accurately.

Table 6: Respondents' Maintenance Practice

Description	Category	Frequency (N)	Percentage (%)
Tyre Status (Tread)	Healthy	139	47.6
	Unhealthy	153	52.4
Tyre Blending	Matching	199	68.2
	Unmatching	93	31.8
Tyre Expiry	Due	259	88.7
	Undue	33	11.3
Road Worthy Certificate	Expired	21	7.2
	Not Expired	271	92.8

The interview sessions on tyre profile arithmetic parameters were followed with physical checks on the tyres of respondents to ensure maintenance practices. Table 6 shows that out of 292 respondents who had vehicles for the study, 52% had unhealthy tyres in their vehicles. 68.2% of respondents with cars had proper tyre mixing where all their four tyres has similar or the same specifications. It was observed that 88.7% which is 259 out of 292 respondents with vehicles had 2 or more of their tyres already elapsed 6years from the date of manufacture meanwhile 92.8% of these vehicles had their roadworthy up to date.

IX. Discussions and Conclusions

Arguably most of the respondents disagreed that car tyres have expiry dates regardless of manufacturing dates and life span of 6years as asserted in studies including (Chen 2018; Virkar et al 2013; Abdul Khalid et al 2018). Respondents were aware of tyre treads and do replace deformed tyres with symptoms like cracks and wear outs. Car users could identify the rim diameter of car tyres, especially with the aid of the letter **R** attached to the size number. Drivers showed awareness and understanding of tyre inflation pressure and usually ensure that vulcanizers inflate the appropriate air pressure. Meanwhile, a significant number of vehicle users couldn't tell where to locate their vehicle tyre specification details on their cars. This may be due to the absence of vehicle user manuals and placards because most of these cars were "second-hand cars" handled by multiple users. Vehicle users were unable to interpret tyre profiles including; tyre life cycle, tyre blend, tyre speed rating and load index which is not different from the results of a study by Arkoh et al (2018) stating that only 4% of users could read and interpret tyre specification codes.

The majority of the vehicle users carried spare tyres but it was observed that most of them do not regularly check the conditions of their spare tyres until they are in need. Responses from vulcanizers revealed that most vehicle users do not bother about tyre expiry dates but rather prefer tyre fixing to tyre replacements. It is recommended that proper monitoring measures be put in place to ensure that imported tyres are healthy for use. Drivers and Vehicle License Authority (DVLA) must ensure proper tyre status before issuing Road Worthy Certificate. Sensitization campaign towards proper tyre maintenance practices needs to be maximized by the National Road Safety Authority (NRSA) to reduce tyre failure accidents. Leaders of Transport Unions of commercial vehicles need to ensure proper load weight of vehicles before allowing vehicles to set off from their terminals.

Conflict of Interest

The authors declare no competing financial interest.

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