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SURVEY ON ROAD-TYRE CONTACT PATCH PATTERN AND WEAR RELATED ASPECTS

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Abstract: Motor vehicle end-users approaches to tyre safety issues in automobiles translate to a number of tyre failure risk factors. This study basically assessed tread wear pattern of tyres in passenger cars used on Nigeria roads. The result obtained showed that 75.4% of the assessed tyres showed uneven wear pattern resulting from incorrect tyre-road contact effects. This observed high proportion of uneven tyre tread wear pattern implies high rate of inconsequential regard for tyre safety.

KEYWORDS: safety; tyre; road; wear; tread; vehicle

1 Introduction

Every modern passenger car is adapted with a very complex and complicated structured component that impacts vehicle performance and its behaviour in several ways called tyre [1, 2, 3]. Tyres among other functions have significant safety impact on every road vehicle trip [2, 4]. Every controlling and maneuvering function in automobiles initiated by either the driver (steering, braking or accelerating) or active safety systems (anti-lock braking system ABS, electronic stability control ESC, traction control TCS) ends up being transmitted to the tyres [2, 4]. Tyre constitutes many structural elements with the casing assembly (textile cord ply, inner liner, side wall and bead core) as well as tread and belt assembly (tread, joint-less cap plies and steel-cord belt plies). These structural elements adapts tyres with a number of functions such as cushion, dampen, directional stability minimal rolling resistance, optimal handling and long service life. Tread, the outmost surface of the tyre that comes in contact with the road surface contains patterns of grooves, lugs, voids and sipes for good amount of traction on different kinds of road surfaces, while being durable [5, 3].

Road vehicles safety and ride comfort are dependent on one, or a combination of the following complex but interconnected factors; human, vehicle, road and environmental factors [6]. The state of the vehicle material and road safety influence ride comfort thereby affecting the driver's health (fatigue). Accident causation factors found in literatures particularly in developing nations includes low road construction standards, poor road conditions (potholes, uneven road surface, settlement, uneven pavement, patchy repair works, uneven pavement) and traffic infrastructure, roadworthiness of vehicles, poor maintenance culture, rapid urbanization process, high population growth rates, reckless driving, little or no appropriate safety measures, non adherence to road traffic safety rules and regulations and high dependency on public transport for daily movement [7-9]. Vehicle maintenance for safety and ride comfort involves paying particular attention to the tyres brakes steering and other safety systems. These enhance the vehicle safety. Tyres flex and heat during wheel rotation. Flexing and heating of an inappropriately inflated tyre causes structural internal damagesof the tyre and hence increases the tyre failure potential. This demands accuracy in

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tyre pressure inflation and wheel alignment. Service conditions factors considered for road tyre safety include vehicle tyre maintenance history, storage conditions, visual inspections and dynamic performance.

Tyre service life ends when the tread has worn down to minimum depth, damage or abused (punctures, cuts, impacts, cracks, bulges, under-inflation, overloading etc.). Also tyre driving safety factors upon usage must consider environmental factors such as climatic conditions, Ultraviolet radiation and ozone. In addition the vehicle related factors have substantial influence concerning parameters of chassia geometry (camber, toe), drive concept het flow wheel loads speed and wheel slip [10]. Accepting road safety practice cut across different age group, gender, personality and ethnicity. On the road safety comprises compliance with the safety practices and assiduousness in decision-making. This involves observance of the equipped tire pressure monitoring system (TMPS) for vehicle tyre air pressure, plying speed on different road surfaces (wet or dry) and electronic stability control (ESC) system. Safety components and accessories are adapted to vehicle for rider's safety and comfort [11].

Lupker et al. (2002) observed that the nature of tyre-road contact affects their wear pattern and the grip level as the wear energy factor between them is the same [12]. Tyre is affected by the normal pressure distribution on a tread element, which is directly affected by road surface texture. According to [3, 4], tyre-road grips are essentially attributed to two primary effects, molecular adhesion and hysteresis grip. While molecular adhesion deals with interactions at the molecular level at the tyre/road interface, hysteresis grip deals with energy absorption during loading and unloading of the vehicles [3, 4]. Road holding quality or the road-tyre grip level of tyre has effect on its performance such as the ability of tyre to transmit strong longitudinal and lateral forces during acceleration, braking and cornering maneuvers on different road conditions [13, 3]. The tyre grip level is mainly affected by meteorological influences in combination with the tyre condition (tread depth, ageing, inflation pressure), and tyre choice [4]. Tyre grip performance on wet roads is better with increased tread depth as it increases the speed that can be driven without aquaplaning and shortens braking distance.

Defective tyre according to studies [2, 4, 14] loses some of its dominant factors like road vehicle stability, steerability, ride safety and driving comfort. Reduction in tyre grip on wet roads is basically found when the tyres treads wear below the safe acceptable tread depth specifications [4, 15]. When this happens it extends the vehicle's stopping distance and as well cause vehicle instability [13]. Tyre blowout failure risk is related to inflation pressure being too low, tyre damage and ageing effects which are strongly linked to tyre maintenance. The incidence of tyre blowout failure leaves its debris on the road and makes the vehicle unstable. This can stop the vehicle at any instance and in an unsafe location for it to be fixed [4]. Both the grip performance and the risk of tyre blowout failure are affected by inflation pressure. A wide variation in tyre inflation pressure reduces tyre grip level as such can lead to vehicle instability. This also affects the vehicle tyres on dry roads due to the reduced stiffness. Tyre blowout failure can occur due to heat generation from large tyre deformations that result from severe under inflation [4, 10, 16].

A vast majority are pneumatic tyres (tubed and tubeless), comprises a doughnut shaped body of cords and wires encased in rubber and generally filled with compressed air to form an inflatable cushion; the body ensures support. Tyres upon usage are susceptible to distinct tyre-road contact surface changes under diversified conditions [2]. The complexity of tyre wear changes depends non-linearly on a number of factors namely tyre compound and design (rubber mix properties, tread pattern, etc.), vehicle type and usage (tyre inflation pressure, normal load, wheel alignment, etc.), road conditions and road surface characteristics (surfacing texture, etc.) and environmental conditions (temperature, etc.) [2, 6, 17]. Ideally vehicle tyres should have rectangle contact patch shape with the road surface thereby resulting to normal tread wear (even wear). However in practice tread wear could be abnormal (uneven wear) resulting from poor wheel alignment, and incorrect tyre inflation pressures. This require that vehicle end users need to make the correct assessment in relation to the tyre condition in order to achieve a level of safety as high as possible [4]. Determining tyre contact patch pattern of vehicle tyres is normal conducted when the vehicle is in static position [18]. The road-tyre contact patch pattern assessment and substantial influence concerning parameters of chassis geometry and tyre inflation pressures wear effect in passenger cars used in Abeokuta metropolis.

2 Materials and Methods

This cross-sectional study of road-tyre contact patch pattern of vehicle owned and used in Abeokuta metropolis Ogun state, Nigeria was carried out from 31st day of March to December, 2016. A total number of four hundred and seventy-two (472) tyres on one hundred and thirteen (113) passenger cars used as study sample selected using a systematic sampling approach. This was after permission was obtained from vehicle owners contacted gave their permission. Quantitative data concerning the tyre thread wear pattern was obtained through tyre tread depth measurement using handheld tyre tread gauge. The tyre tread depth measurement was taken at three different strategic spots (inner-edge, outer-edge and at the center) at three different positions (tyre front, upper and back part) on the tyre rolling surfaces. The wear pattern obtained for each of the vehicles tyres were recorded and analysed under the following subheading, even and uneven wears. Elaborately, the uneven wears were classified as improper inflation pressure (under-inflation and over-inflation) and out-of-spec tire alignment (heel/toe tire wear, feather edge tire wear and one-sided shoulder tire wear) effects. The following served as guide for classification of the vehicles tyre uneven tyre wear contact patch pattern

Improper inflation pressure

Under-inflation; wear at the edges of the tyre tread (Figure 1) [16, 19].

Figure 1. Wear due to under inflation (https://www.rv.net)

Over-inflation of tyre; wear at the middle of the tyre tread (Figure 2) [16, 19].

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Figure 2. Wear due to over inflation (https://www.rv.net)

Poor wheel alignment

Heel/toe tire wear; circumferential faster of one side of the tread than the other side (Figure 3) [16, 19].

Figure 3. Wear due to heel and toe effects (https://www.rv.net)

Feather edge tire wear; worn lower/smoother on one side and higher/sharper on the other on the tread ribs (Figure 4) [16, 19].

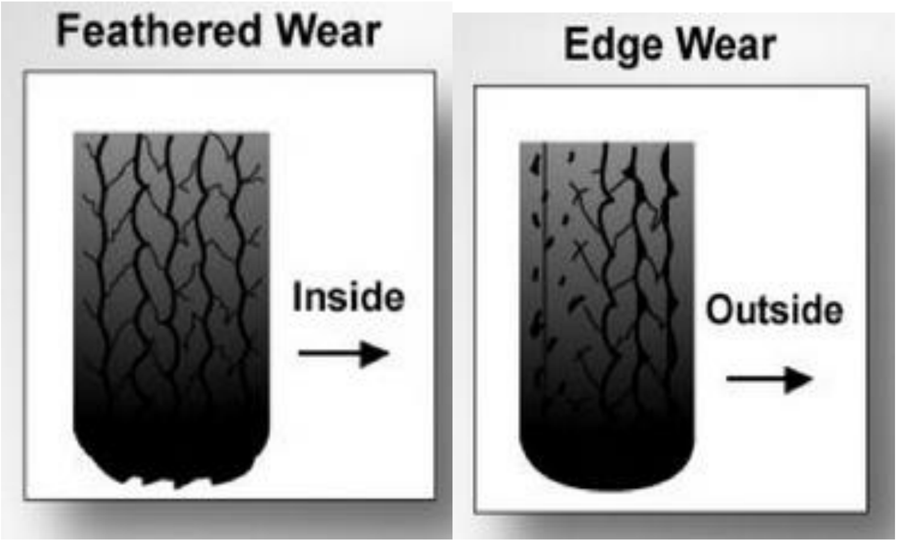

Figure 4. Wear due to feathered edge (https://www.rv.net)

One-sided shoulder tire wear; significant inside or outside shoulder tread rib more worn than the other (Figure 5) [16, 19].

Figure 5. Wear due to shoulder wear (https://www.rv.net)

Those which do not fall into any of these categories were excluded in this study. Analysis of data obtained was done using statistical package for social science SPSS version 16.0. The proportions of each category were presented in frequency and percentage formats.

3 Results and Discussions

The wear pattern of the four hundred and seventy-two tyres assessed in one hundred and thirteen passenger vehicles showed proportionate ratio of 116(24.6%) and 356(75.4%) for even wear pattern and uneven wear contact patch pattern respectively. Analysis carried out to showed uneven wear causation factors as uneven tyre tread wears may occur as a result of incorrect tyre inflation pressures and/or poor alignments showed that 201/472 representing 42.6% of the total number of assessed tyre were uneven wear due to incorrect inflation pressures; which were 48/472 (10.2%) for over-inflation and under-inflation 153/472 (32.4%). The second dimension of uneven wear patterns assessed was tread wear due to poor or vehicle wheel misalignment with the chassis geometry. The three aspects looked into from which the analysis was conducted, toe tire wear, feather edge tire wear and one-sided shoulder tire wear showed respective tread wear pattern of 15.9%, 13.3% and 3.6%. Operational deviations of tyres from the appropriate specification inflation pressures and chassis geometry configuration can be detected through regularly tread depth check and wear condition of each of the tyres on the vehicle. The proportion of the high uneven wear pattern agreed with [16] that vehicle owners do not care about their vehicle tyres as much as they do to other parts of the vehicle. As well it buttressed institute for accident analysis facts [20] that tyres defects emanates from inappropriate inflation pressures, bad vehicle tyres installation etc. In addition uneven tread wear of road-vehicle tyres affects the safety status and replacement time even when within its shelf life. Rapid reductions of tyres tread through tread wear have effect on rolling resistance thereby requiring earlier replacement as well affect increase fuel consumption of vehicles. Replacement of tyre at every moment the minimum tread depth requirement is passed can lead to higher cost of tyre maintenance or replacement and environmental burden due to waste increase [4]. Lack of appropriate vehicle tyre maintenance results in diverse dimensions of incidence (accidents and near-misses) and this according to [10] contribute to the accidents' involving technical failures of tyres.

Table 1. Road-tyre contact patch pattern and wear related aspects

Characteristics/variables	Frequency (n)	Percentage (%)
Even wear	116	24.6
Over-inflation	48	10.2
Under-inflation	153	32.4
Toe tire wear	75	15.9
Feather edge tire wear	63	13.3
One-sided shoulder tire wear	17	3.6
Total	472	100.0

4 Conclusion

Tyre plays a dominant role in determining the stability, steerability, safety and comfort driving performance of vehicles on the road. This can only be achieved if vehicle owners/drivers make proper assessment of their vehicle tyres for appropriate level of traction. Observation made in this study showed high uneven tyre tread wear proportion emanating from incorrect tyre pressures and poor wheel alignments which simply implies poor maintenance of vehicle tyres. The main safety aspects of road vehicle involving tyre failures remedy require appropriate consideration of road-tyre contact patch pattern and good tyre grip level of vehicle tyres.

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