DEVELOPMENT OF SYSTEMS AND AUXILIARY EQUIPMENT FOR IMPROVED RELIABILITY OF USED TYRES

BY

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CERTIFICATION

This is to certify that the project was carried out by DAFE, TIMOTHY SIVWENOJA in the Department of Mechanical Engineering, School of Engineering and Engineering Technology, Federal University of Technology, Akure, Ondo State.

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DEDICATION

This project is dedicated to God the Almighty Father for the gift of a baby girl, Miss Mary Magdalene Oghenerukeme Dafe. The project also dedicated to all who engage in making life comfortable for the less privileged Nigerians, especially Dr. Dora Akinyuli of NAFDAC.

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ABSTRACT

The standardisation of tyre, its safety and maintenance cannot be over emphasized. How reliable are second-hand tyres and their possibility that they will not fail in use, and how efficient are the quality of work done by local/roadside vulcanizers. This thesis assesses and evaluates the reliability of automobile tyres in Nigeria, especially the second-hand tyres popularly called "Tokunbo" tyres and embark on the development of a machine that helps in the removing or fixing of tyre on a car rim when either a tube is to be removed or a tyre is to be removed from a car rim during vulcanisation. This machine is an improvement on the type of tools/implements used by local/roadside vulcanizers. This device laid emphasis on solving some of the problems facing the local/roadside vulcanizers and the various factors causing damages on tyres.

An analysis of tyre users and sellers in Nigeria was done in order to determine their knowledge and safety consciousness and the means of identifying a legally acceptable second-hand tyre were also looked into. This project also exposes and analysed the non- public existence of tyre safety and standards in Nigeria by the federal agencies saddled with this responsibility, for example Standards Orgainsation of Nigeria, Federal Road Safety Corps, The Nigeria Customs Service, e.t.c. Also the method of operation of some local/roadside vulcanizers and that of well-established tyre workshops were observed and based on lapses observed a manual tyre removing and fixing device was constructed using the principle of power transmission via a pinion and bevel gear arrangement. The constructed device was tested in order to determine the time it would take to remove or fix a tyre from or into a car rim, numbers of wounds that would be inflicted on the tyre bead during vulcanization.

The results of the test shows that using the constructed device for vulcanization, no wound is inflicted on the tyre bead either when a tyre is being removed or fixed from or into a car rim. It also shows that it takes an average of 3mins to break the bead of a tyre, 2mins and 3mins to remove and fix a tyre bead from or into a car rim respectively. The method of operating the machine is simple. The machine ensures a safe working condition with little maintenance while the cost of production is not as much as that of an imported tyre removing/fixing machine.

Suggestions on tyre safety tips were given and a means of assisting second-hand tyre buyers was suggested, including what to look out for while buying a second-hand tyre in order to prevent tyre failure in use.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER ONE
INTRODUCTION

1.1 Introduction

In the automobile industry, the part that tyres play cannot be over-emphasised and interestingly tyres are directly or indirectly used by all in Nigeria. Automobile provides the only visible means of transportation in Nigeria. It is pertinent to note that most writers, researchers, users and vulcanizers do not take cognisance on the important role it plays in our daily life. Retreaded, second-hand tyres with little or no tread pattern termed imported (Tokunbo) tyres are in the Nigerian market to the detriment of users safety.

The cost of part-worn tyres reflects their second-hand state and this no doubt contributes to their attraction to motorists. The purchase and use of part-worn, instead of new, tyres may enable some owners to afford to keep their vehicles on the road. The tyre industry continues to express concern about the sale and use of part worn tyres. However, it is important to consider the issue objectively and make a reasoned judgment about the real risks of using such tyres.

Tyre repairs, which range from patching of inner tube or its outright replacement to the renewal of old tyres with new ones, or at times the replacement of the rim, constitute a very significant part of automobile maintenance. These removing and replacement processes basically involve the removal of deflated tyre from the rim, which comprise pressing, forcing, clamping and rotating. All these require a high human effort to undertake.

Observations had revealed that apart from the use of locally-fabricated tools and loss of energy used by local or roadside vulcanizers during the process of either removing or re-fixing tyre into a car rim, a lot of damages are inflicted on the tyre rim. Having recognized this problem, a study was carried out to determine the methodology of carrying out this project. This is to determine whether the machine is needed in the society or not and if it is needed why it is so. The need was eventually verified from the increase in damages to tyres due to poor methods of tyre maintenance which are attributed to the tools and equipment used by the local or roadside vulcanizers.

Six roadside vulcanizers were visited and observed on how they work with their equipment and tools. It was discovered that they all had similar problems and shortcomings in their methods of operation and tools used. Also some big organizations, namely, Dunlop Nigeria Plc, Michelin Nigeria Plc, Leventis Motors Plc, Nigeria Ports Authority, Moragoff Arrow Int. Ltd., Mandillas Enterprises Ltd was visited. Their machines were examined and operated. It was observed that the designs of these machines are good and efficient in operation, but they are beyond the reach of the common man. Their component parts are expensive and are not readily available in the market.

Between 1998 and 200, a total of 68,396 road traffic accidents were recorded in Nigeria. Within this same period, 33,689 persons died. The Standard Organisation of Nigeria informed that 65 percent of road accidents recorded over this period were due to bad tyres. It also indicated that 77 percent of the accidents arising from bad tyres were directly linked to various brands of sub-standard brands imported into the country (The News Magazine, 2004)

Since the use of second hand tyres may be difficult to stop it becomes pertinent that buyers should be able to know the causes for tyre wear, tear, and all other factors relating to tyre safety and proper maintenance. A tyre buyer should be able to know easily the condition of the tyre he wants to buy especially second-hand tyres.

1.2 Objectives

The objectives of the project are to:

i. determine the reliability of tyres in use.

ii. develop a method for predicting tyres failures.

iii. prescribe maintenance system for tyre.

iv. eliminate damages inflicted on tyres or rims during the process of removing or fixing tyres on car rims by local / roadside vulcanizers.

v. reduce energy dissipitated by local / roadside vulcanizers during the process of removing or fixing tyres on a car rim.

vi. increase productivity through the development of a simple device to remove or fix tyre on a car rim; an improvement on local / roadside vulcanizers implements.

1.3 Methodology

Preliminary studies were carried out on tyre construction; types of tyres, tyre making, e.t.c. Field surveys through questionnaires were administered and visitations were carried out to tyre buyers, sellers and vulcanizers to determine their understanding of tyres especially on used tyres.

Evaluation based on the responses received was done to assess how conscious and knowledgeable tyre users and sellers are on tyre safety and maintenance. A method on how to check for used tyres in order to buy a legally acceptable part worn tyre was developed while proper tyre safety and maintenance tips were enunciated.

The research also consists of the design of a simple device for removing or fixing tyres on a car rim after detailed study of existing tyre removing devices; local and foreign.

1.4 Expected Contribution to Knowledge

The study will promote road safety through appropriate guidelines for categorizing tyres (both new and used). It will also assist in instituting sustainable maintenance strategies and safety regulations. It will also improve the productivity of tyre removing or fixing processes while prolonging the life span of both tyres or rims due to reduction or elimination of damages inflicted on them during the process of removing or fixing.

CHAPTER TWO
LITERATURE REVIEW.

2.1 Evaluation

Brainy Dictionary (2004) defines evaluation as an act of ascertaining or fixing the value or worth of or as an appraisal of the value of something. Barbra Dictionary (2004) defines evaluation as a process for enhancing knowledge and decision-making within organizations and communities. It involves answering questions and/or addressing issues through the collection and analysis of information about programs, systems, processes, procedures, products, and services. Evaluation is best implemented as a systematic process that is planned and purposeful, and with a clear intention of using the evaluation findings. Evaluation is a means for understanding what we do and the effects of our actions in the context of the work environment and the society in which we live.

EUROPA (2002) defines evaluation as an assessment, as systematic and objective as possible, of on-going and completed projects, programmes and policies, as regards their design, implementation and results. Evaluation is an activity which is generally carried out before a programme begins (ex-ante), in mid-cycle before renewal or cancellation (mid-term), or at the end when impact can be measured (ex-post). To evaluate is to assess or appraise. Evaluation is the process of examining a subject and rating it based on its important features. We determine how much or how little we value something, arriving at our judgment on the basis of criteria that we can define.

Oloyo (2001) opined that evaluation research is conducted to determine the relative worth or usefulness of two or more alternative actions. Its outcome does facilitate the researcher's decision on the best alternative. The conclusion as to the choice of the best alternative must be based on systematic process of collecting and analysing pertinent data on the research subjects. As part of the advantages of this type of research, it reveals information about shortcomings of each alternative and thus identifies points or areas where improvement can be made.

2.2 Reliability

Hornby (1995) defines reliability as something consistently good in quality or performance and able to be trusted. Brainy Dictionary (2004) defines reliability as the state or quality of being reliable; reliable being something suitable or fit to be relied on; worthy of dependence or reliance.

Leitch (1988) opined that reliability of a piece of equipment or device as its ability to perform a specified task, for a specified time, in a specified environment. It is measured as a probability. To achieve equipment reliability, reliability must be considered as important parameter in the equipment specification as weight, speed, cost, fuel consumption, e.t.c.

2.3 Motor Vehicle Tyres

French (1990) defined tyres as rubber and fabric devices that, when attached to the wheels of a vehicle, provide the contact between the vehicle and the surface over which it travels. Tyres also improve comfort whilst carrying the weight of the vehicle. They are the only contact with the road and affect the steering, braking, and acceleration of the vehicle. Tyres may be either solid or pneumatic (air filled) in structure, with the latter being the most prevalent today. French (1989) opined that each modern automotive tyre supports 50 times its own weight. Compressed air within the tyres carry 90 percent of the load, with the tyres complex structure of rubber and fabric carrying the remaining 10 percent.

2.4 History

French (1990) states that Robert W Thomson patented the first pneumatic tyre in 1845. His "elastic bearings" for carriages were made from several layers of rubber saturated canvas. Before the development of tyres, metal rims protected wheels. Later solid rubber tyres in a metal channel were used, first being made by the British inventor Thomas Hancock in 1984 for light horse-drawn vehicles and bicycles. Solid rubber tyres are still used on some tractors and lorries. The British Engineer Robert Thomson first patented pneumatic tyres in 1845; John Dunlop first produced them commercially in 1888.

However, the pneumatic tyre was not generally adopted until the invention of the dished wheel-rim, patented in 1890 by the British Engineer C. K. Welch. By 1900 and the dawn of the automobile age, tyres had round cross-sections, separate inner tubes inflated to a pressure of 5 kg per sq.cm. and rubber coated, cotton cloth covers. Treads, which alleviates the danger of sideslip, were introduced about 1910.

By 1916 pneumatic tyres were standard on most passenger vehicles and lorries. Layers of reinforcing cord was introduced in 1920s, white walls followed in 1929. The 1930s saw the introduction of synthetic rubber made from petrochemicals. The last major change, elimination of separate inner tubes came in 1954. Modern motor-car tyres are generally tubeless and radially built, comprising of rubberised fabric with steel reinforcement.

2.5 The Making of a Tyre

According to Wilson (2000), tyre manufacturing is a complex technical process, which, for the sake of simplicity can be broken down into eight manufacturing stages:

1) Mixing

Various grades of natural and synthetic rubber are blended in an internal mixer (commonly known as a Banbury) and mixed with carbon black and other chemical products. This blend is called the "master batch" and its make-up is carefully constructed according to the desired performance parameters of the tyre.

2) Calendering

Textile fabric or steel cord is coated with a film of rubber on both sides. Calendered textiles such as rayon, nylon and polyester are used for the casing and the cap plies. Steel cord is used for the belts.

3) Tread and Sidewall Extrusion

The tread and sidewalls are constructed by forming two different and specifically designed compounds into tread profiles by feeding the rubber through an extruder. Extruders produce continuous lengths of tread rubber, which are then cooled and cut, to specific lengths.

4) Bead Construction

The bead core is constructed by coating plated steel wires, which are wound on a bead former by a given number of turns to provide a specific diameter and strength for a particular tyre.

5) Tyre Building

Tyre building is traditionally a two-stage process. Although modern tyre factories now use a certain number of single-stage building machines, two-stage building is still widely used, particularly for the more standard sizes. In the first stage, the inner-liner, the body plies and the sidewalls are placed on a building drum. The beads are then positioned, the ply edges are turned around the bead core and the sidewalls are simultaneously moved into position. In the second tyre building stage, the tyre is shaped by inflation with two belts, a cap ply and the tread being added. At the end of this stage the tyre is now known as a "green tyre".

6) Curing

The green tyre is now placed in a mould inside a curing press and cured for a specific length of time at a specific pressure and temperature. The finished tyre is then ejected from the mould.

7) Trimming

Excess rubber is removed from the cured tyre on a trimming machine.

8) Inspection

Before the tyre is allowed to go to the despatch warehouse, it is inspected both visually and electronically for quality and uniformity.

2.6 Construction

The most visible part of a tyre is the tread (Figure 1), which grips the road surface, and the supporting sidewalls, which run from tread to wheel rim. According to French (1989), tread patterns are especially important when the road is wet. The forward portion of a tyre's contact patch wipes away water so that the rest of the patch grips a drier surface. Continuous channels from the center to the edge of the tread, water will form a wedge and cause the tyre to lift off the road. This so-called "aquaplaning phenomenon" is one reason that smooth tyres are dangerous in wet conditions. Snow tyres and off-highway tyres have deeper treads or separate cleats that bite through snow, slush or dirt to grip the firmer surface beneath.

A tyre's sidewalls have two conflicting purposes: They flex up and down, helping cushion the vehicle from the road irregularities, yet they must be relatively rigid horizontally in order to transfer loads of steering, braking and acceleration. At their innermost edges, sidewalls meet the tyre's beads (hoops of steel wire covered with hard rubber). Each bead reinforces the interface between the tyre and wheel rim and fixes the tyre's inner diameter.

Tyre construction begins with the sidewall. The different rubber compounds necessitated by the different requirements of each part of the tyre are brought together to form sidewall-tread-sidewall strips. Beads are formed from wound and rubber-coated steel wires. Steel or synthetic fibre fabric is rubber coated and cut either at an angle or straight across, depending on tyre type. All these materials are assembled for hand lay up on a rotating collapsible drum.

The operator carefully aligns the reinforcing fabric over a rubber liner. A heated press moulds the tread pattern and vulcanises the rubber.

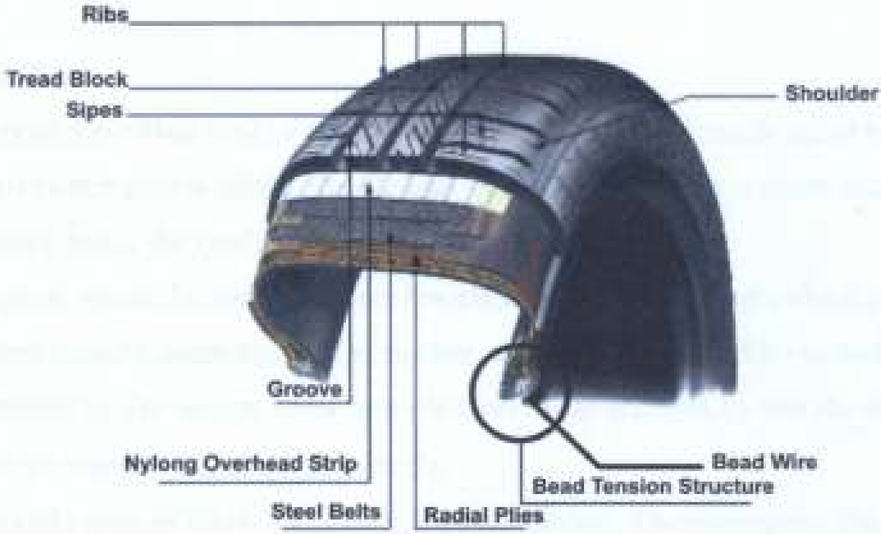


Figure 1: Tyre Tread
Source: Michelin (1997)

2.7 Types of Tyres

Motor vehicles tyres can be divided into three parts namely, tubed tyres, tubeless tyres and solid tyres. Though tubed and tubeless tyres are still in use today, however, tubeless tyres are most common in developed countries. This is as a result of the added advantages it has over tubed tyres. The solid tyres are mostly used in heavy vehicles like trucks, earth moving machinery, industrial tractors, e.t.c. These are solid mass of rubber that does not require any air intake, and are susceptible to wear and tears alone.

The major advantages of tubeless tyres over tubed tyres are

i. The rate of tyre puncture is lower in tubeless tyres than that of tubed tyres because they are made stronger and thicker.

ii. The cost of vulcanising the tubeless tyre is less than that of tubed tyres since the cost of buying tube is removed.

iii. Tubeless tyres have better degree of track gripping than tubed tyres because they are usually wider in width.

iv. Tubeless tyres do not wear easily when compared to tubed when they are subjected to the same weather conditions.

v. Upon puncture, tubeless tyres can still travel a longer distance than a tubed tyre before the air inside the tyre assembly gets exhausted.

However, tubed tyres are cheaper than tubeless tyres. Tyres are further subdivided according to the type of plies. The three classes of modern tyres can be distinguished by the direction of the cords.

2.7.1 Bias-ply Tyres

This reflects the oldest type of tyre construction. Its carcass is made up of two or more layers or plies of rubber coated fabric. The threads or cords of these layer cross one another at angle (on the bias), hence the tyre's name.

The angle at which the cords intersect has effect on riding comfort (which is greatest at larger angles) and steering accuracy (best at smaller angles) of the tyre; this necessitates yet another compromise in tyre design. Most bias-ply tyres today are built so that the cords intersect the centerline at an angle of 35° to 40°(Figure 2).

Two to eight plies of fabric are used in the tyre carcass. The more plies, the stronger the carcass but the harsher the ride. Six to eight ply tyres are used on trucks. When plies were made of cotton, a good passenger car tyre required at least four plies. New, stronger ply materials such as nylon, rayon, polyester and fibre glass have made it possible to build modern two-ply carcass that is stronger than one of four-ply cotton. The number of plies is not a good indication of tyre strength; tyres are now rated by "load range" (tells how much weight each tyre can support at its maximum allowable inflation pressure). Bias-ply tyres are cheaper than radial tyres.

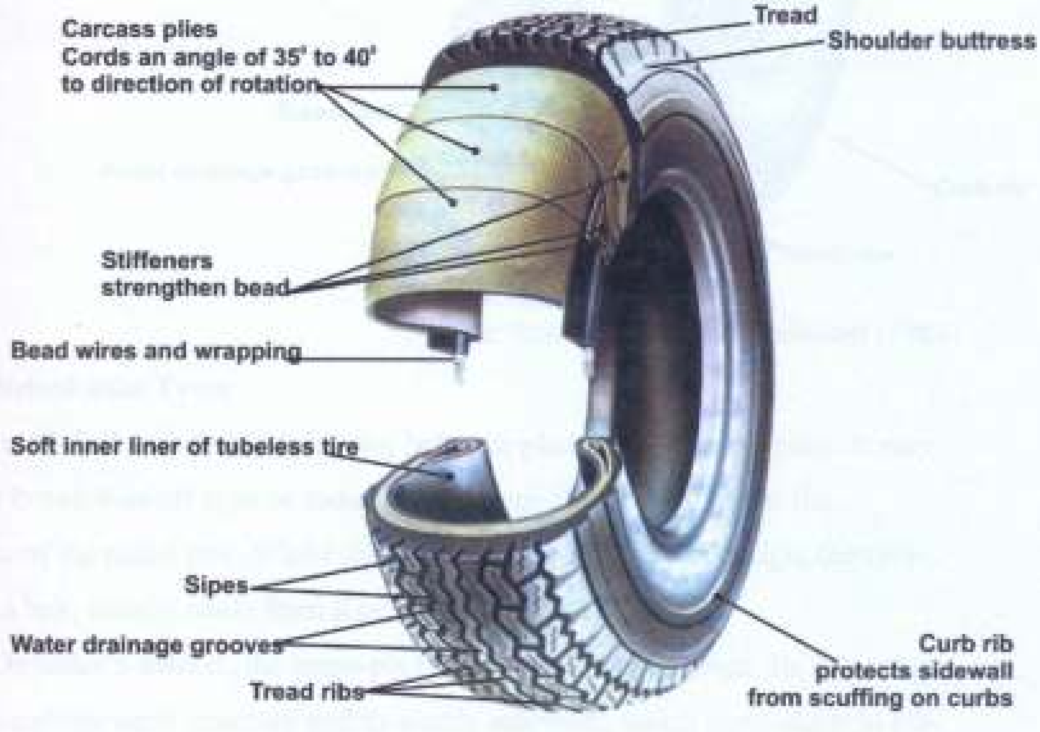


Figure 2: Bias-ply Tyre
Source: Readers Digest Association (1981)

2.7.2 Radial Tyres

Radial tyres are radical breakthroughs in tyre construction. Rather than criss-crossing one another, the parallel plies of a radial tyre radiate from one bead to the other by the shortest possible route, crossing the tread centerline at a 90°angle (Figure 3).

This makes for an extremely flexible sidewall as a soft ride but provides little or no directional stability. Directional stability is supplied by stiff belts of fabric or steel wire that run around the circumference of the tyre between the carcass and the tread. The construction of radial ply tyres reduces cornering wear and increases the overall life of the tyre.

One drawback of radial tyres is that they tend to produce a harsh ride at low speeds, although the ride smoothens out dramatically at highway speeds.

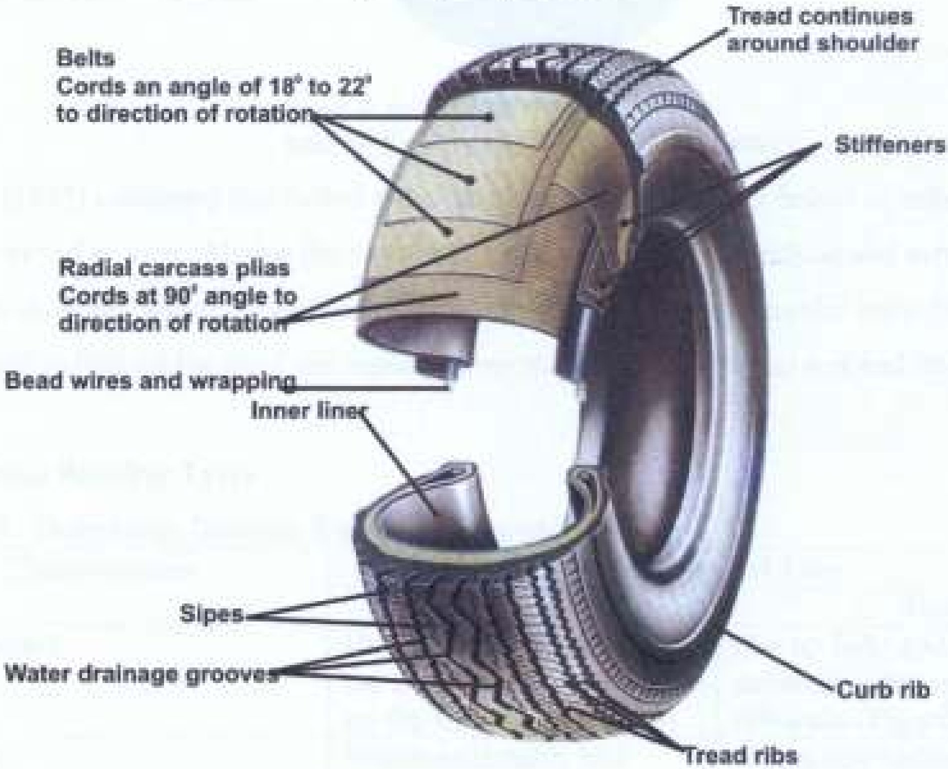


Figure 3: Radial Tyre
Source: Readers Digest Association (1981)

2.7.3 Belted-bias Tyres

In a belted bias tyre, reinforcing belts are placed between the plies. It may be either belted-bias ply type or radial bias ply type Belted-bias tyre is the precursor of the radial tyre. Whilst the casing is still cross-ply in design, the tyre features a belt, usually made from Kevlar.

On today's market, the cross-ply tyre is the "classic" design. Its advantages are its straightforward structure and its sturdy sidewalls, which particularly in off-road use offer many benefits (impact protection) and are suitable for speeds up to

250 km/h (156 mph). The belted-bias tyre can be recognised by the B (belted- bias) in the designation on the outside of the tyre e.g. 150/70 B 17 69H TL Enduro Pro (Figure 4).

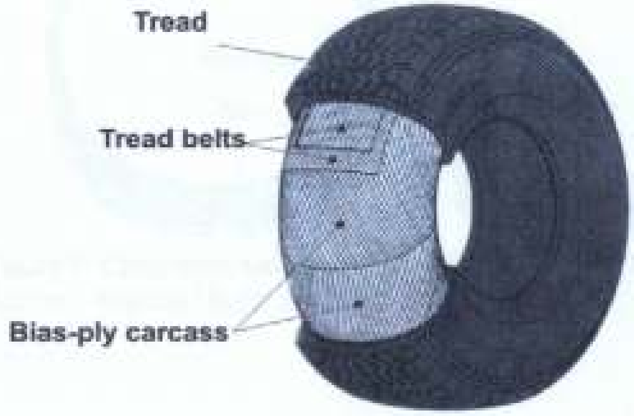


Figure 4: Belted-bias Tyre
Source: Readers Digest Association (1981)

William (1975) cautioned that belted radial and bias ply types, either belted or unbelted should never be mixed in a car. Mixing the two types can cause poor car handling and increase the possibility of skidding, which is essentially important with snow tyres. Regular snow tyres on the rear and belted radials on the front can result in over steer and spin-out on wet and icy roads.

2.8 Radial versus Bias-Ply Tyres

Table 1.0: Differences Between Radial and Bias-ply Tyres.

S/N	Characteristics	Type of Tyre	
		Radial	Bias-ply
1	Cross section	Has reinforcing belts under the tread and the tread runs up the sidewalls(Figure 5)	Has no belts and there is a sharp delineation between tread and sidewalls (Figure 5)
2	Inflation	Bulges noticeably just above the contact area between tyre and road (Figure 6)	A properly inflated bias-ply tyre has nearly straight sidewalls.(Figure 6)
3	Negotiating a curve where centrifugal force tends to pull it towards the outside of the turn.	A radial's flexible sidewall allows the tread to remain flat on the roads for maximum traction. (Figure 7)	A bias-ply tyre's stiff sidewall pulls a portion of the tread away from the road, lessening the contact area and the traction of the tyre (Figure 7)
4	Cost	Costlier	Cheaper.
5	Tread	Very minimal	Higher
6	Fuel economy.	Gives 5 to 7 % better fuel economy due to lower rolling resistance.	Higher than radial.

Source: Readers Digest Association (1981)

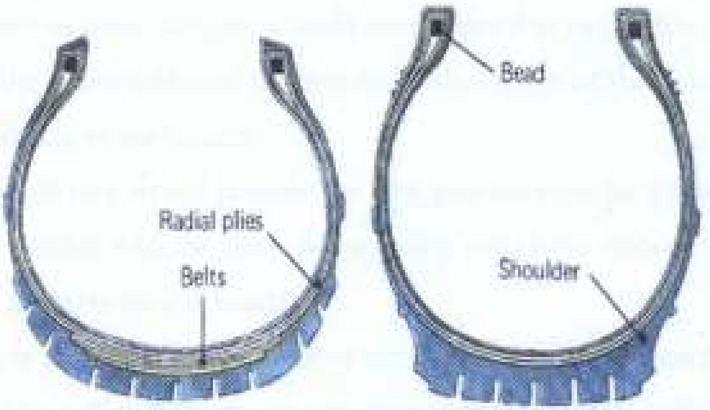


Figure 5: Cross-sectional view of Radial and Bias-ply Tyre
Source: Readers Digest Association (1981)

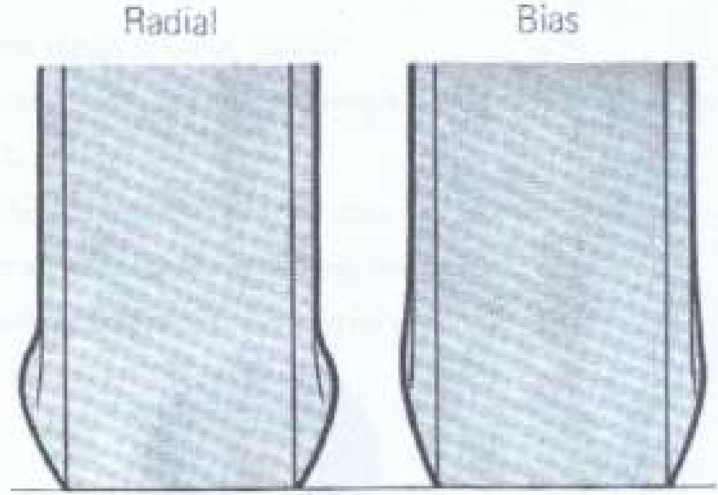


Figure 6: Cross-sectional view of inflated Radial and Bias-ply Tyre
Source: Readers Digest Association (1981)

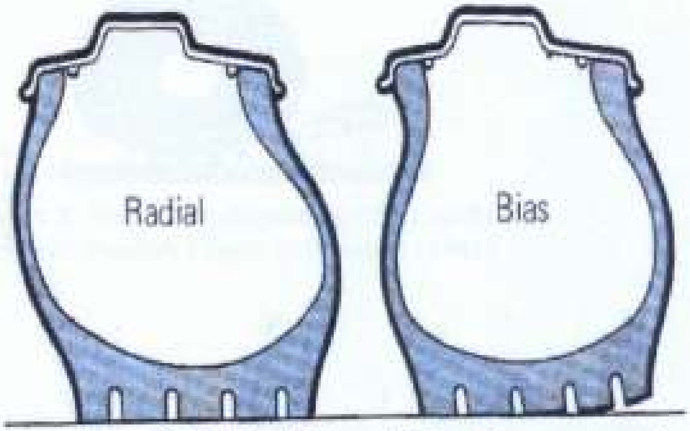


Figure 7: Cross-sectional view of Radial and Bias-ply Tyre when on curved road
Source: Readers Digest Association (1981)

2.9 Tyre Tread

There are many different tread designs. Treads are designed to help tyres grip the road in any kind of weather. Like the construction of the tyre itself, the design of the tread is a compromise between conflicting requirements.

On dry roads, a smooth tyre would provide the best grip because the greatest possible area of rubber would be in contact with the road. Most racing tyres have smooth treads. But smooth treads have hardly any grip on wet roads.

Water causes skids in two ways: A thin film of water can act as a lubricant. Also, puddles can form a wedge in front of a rolling tyre, causing the tyre to ride up on the water like a water ski. This causes a type of skid called "hydroplaning". The tyre is lifted off the road, and all steering and braking control is lost (Figure 8).

Tread ribs do three things in water, namely:

i. They either push the water aside or pump it through zigzag grooves from the front of the tyre contact patch to the back.

ii. The film of water left behind is forced into the sipes-slits like tiny knife cuts. As the tyre revolves beyond the contact area, this water is flung out of the sipes.

iii. The ribs grip the remainder of the now dry contact area.

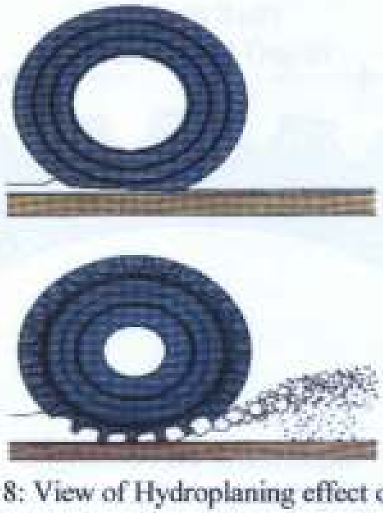


Figure 8: View of Hydroplaning effect on Tyre
Source: Readers Digest Association (1981)

2.10 Tyre Tread Depth

The legal minimum tread depth of the main grooves of car and similar tyres in the United Kingdom and the European Community is 1.66mm (UK Department of Transport, 2003). This applies across the central three quarters of the breath of the tread and round the entire outer circumference of the tyre (Figure 9).

Tyre tread provides the gripping action and traction that prevent a vehicle from slipping and sliding, especially when the road is wet or icy. In general, tyres are not safe and should be replaced when the tread is worn down to 1/16th of an inch. Tyres have built-in tread wear indicators that let a motorist know when they should be replaced. These indicators are raised sections spaced intermittently in the bottom of the tread grooves. When they appear "even" with the outside of the tread, it's time for tyre replacement.

Tyre tread pattern is designed to give good grip in wet conditions. Generally, grip reduces as the tyre wears or as the road surface water depth increases. The 1.66mm minimum limit applies to:

1. Cars and passenger vehicles with up to 8 seated passengers (driver not included).
2. Motor vehicles and light trailers (including caravans) up to 3500kg gross vehicle weight.

Most car tyres have tread wear indicators, usually at least six small ribs across the bottom of the main tread grooves and when the tread surface becomes level with these ribs the tyre is at the legal limit and must be replaced. Simple and cheap gauges are also available to give an acceptable guide to tread depth.

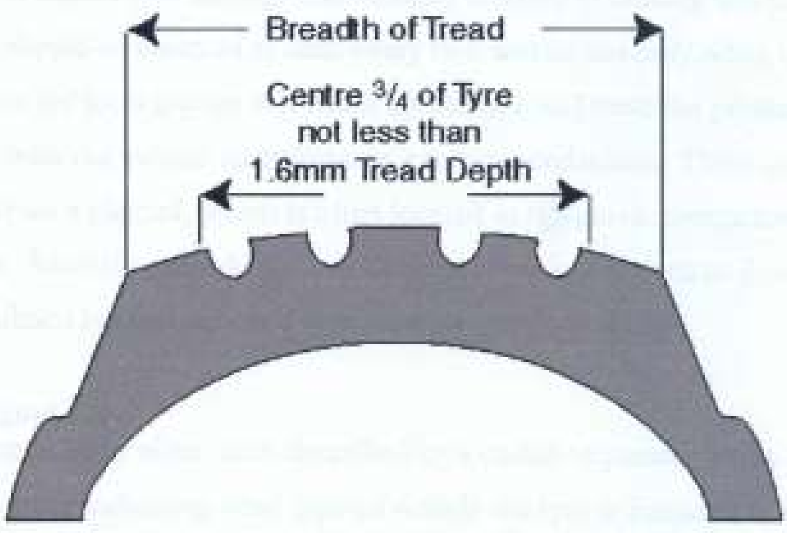


Figure 9: Tyre Tread Depth
Source: UK department of Transport (2003)

2.11 Part-worn Tyres

There are many dangers in buying part-worn or ' second hand' tyres. Their history is unknown and they may have been removed from a vehicle involved in an accident or have been badly damaged by 'kerding' or similar problems. Repairs may not have been carried out properly, for example to British Standard BS AU 159e.

Regulations require a part-worn tyre to be marked "PART-WORN" adjacent to the E e or BS mark, to indicate that it has been properly examined internally and externally before being offered for sale. Some faults only show up if the tyre has been inflated. Tread depth must be at least 2mm across the whole breadth of the tread.

2.12 Mixing of Tyres

Except in the case of temporary use spare tyres, it is illegal in the United Kingdom, and it is certainly dangerous to mix radial-ply and cross-ply tyres on the same axle or to have radial-ply tyres on the front axle and cross-ply tyres on the rear axle. This applies to all two-axle motor vehicles in either front or rear wheel drive. The type of tyre is indicated on the sidewall markings. In the case of radial tyres the word 'radial' is written on the sidewall.

2.13 Tyre Pressures

Correct tyre pressures are vital for safe handling and optimum braking, grip and tyre life. Low tyre pressures or overloading will cause increased fuel consumption, more air pollution, shorter tyre life and greater risk of tyre failure. High tyre pressures may reduce comfort, less grip, greater risk of impact tyre damage and reduced stability in braking and cornering.

Pressures should be checked at least every two weeks and only when the tyres are cold. Even a short trip to the local garage will warm up the tyre and raise the pressure. Tyres should be inflated in accord with the vehicle manufacturer's recommendations. These can be found in the owner's manual or on a placard, which is often located in the glove compartment or on the driver's doorjamb. Motorists should not rely on visual tyre inspections to determine whether a tyre is properly inflated but should use a tyre pressure gauge to do so.

2.14 Tyre Designations

Tyres come in many sizes, each described by a coded sequence. Some size designations are preceded by a letter indicating what type of vehicle the tyre is intended for. "P," which stands for "passenger," is the most common. "LT," which stands for "light truck," is also common. Figure 10 shows an example of a tyre marking; 205/55/R16 88V.

The first number 205 is a three-digit number, which refers to the overall width of the tyre, in millimeters. The second number 55 refers to the aspect ratio, which is the relationship between the tyre's height and it's width. In this example, the sidewall's height is about 55% of the tyre's width. The letter following the aspect ratio is an "R," standing for "radial."

The next number indicates the diameter of the wheel rim on which the tyre will fit 16 inches (40.64cm) in this example. The final number and letter represent the service description, or load index and speed rating. The load index is an assigned number ranging from 0 to 279 that corresponds with the load carrying capacity of the tyre; that is, how much weight it is certified to carry at maximum inflation pressure. The rating can be matched against a load index chart (Table 2.1) to determine corresponding maximum weights. A load index rating of 88 indicates a maximum load of 560 kg (1,235 lbs).

The speed rating is a letter, which indicates the range of speeds at which a tyre is certified to carry a load. Each tyre is assigned a rating from A (lowest) to Z (highest). There is one notable exception: the "H" rating falls out of sequence between "U" and "V," and is used for tyres certified for speeds up to 130 mph. The Q rating is the lowest commonly used for passenger cars. A "V" -rated tyre is certified up to 240 km/h or 149 mph.

Because of different handling characteristics, tyre of different size and type should not be mixed.

Figure 10: Sidewall Marking of Tyre
Source: Michelin (1997)

Table 2.1: Load Index and Speed Reading of Tyre

Load Index	Load in Kg per tyre	Load Index	Load in Kg per tyre	Load Index	Load in Kg per tyre	Load Index	Load in Kg per tyre	Load Index	Load in Kg per tyre	Speed Symbol	Speed in km/h
62	265	75	387	88	560	101	825	114	1180	J	100
63	272	76	400	89	580	102	850	115	1215	K	110
64	280	77	412	90	600	103	875	116	1250	L	120
65	290	78	425	91	615	104	900	117	1285	M	130
66	300	79	437	92	630	105	925	118	1320	N	140
67	307	80	450	93	650	106	950	119	1360	P	150
68	315	81	462	94	670	107	975	120	1400	Q	160
69	325	82	475	95	690	108	1000	121	1450	R	170
70	335	83	487	96	710	109	1030	122	1500	S	180
71	345	84	500	97	730	110	1060	123	1550	T	190
72	355	85	515	98	750	111	1090	124	1600	H	210
73	365	86	530	99	775	112	1120	125	1650	V	240
74	375	87	545	100	800	113	1150	126	1700	W	270
										Y	300

Source: Michelin (1997)

Other markings on tyres are (Figure 11):

1. Maximum Load, Maximum Inflation.

For passenger tyres, the maximum load and maximum inflation markings indicate the maximum load that can be carried at the maximum pressure. For light truck tyres, it is stated in direct relationship to the maximum load capacity and inflation pressure.

2. DOT Markings

Essentially the DOT marking serves as the tyre's fingerprint. DOT signifies that the tyre complies with U.S. Department of Transportation Tyre Safety Standards, and is permitted for highway use. For example refer to the following markings: DOT M5H3 459X 064. The first letter and number following DOT designate the tyre's manufacturer and plant code. The third, fourth and fifth number and letter, 59X, is the tyre size code which is an optional manufacturers code that identifies the tyre size and other specific characteristics of the tyre. The final three numbers denote when the tyre was produced, with the first two indicating the week, and the last number indicating the year (064 indicates the tire was built in the 6th week of 1994).

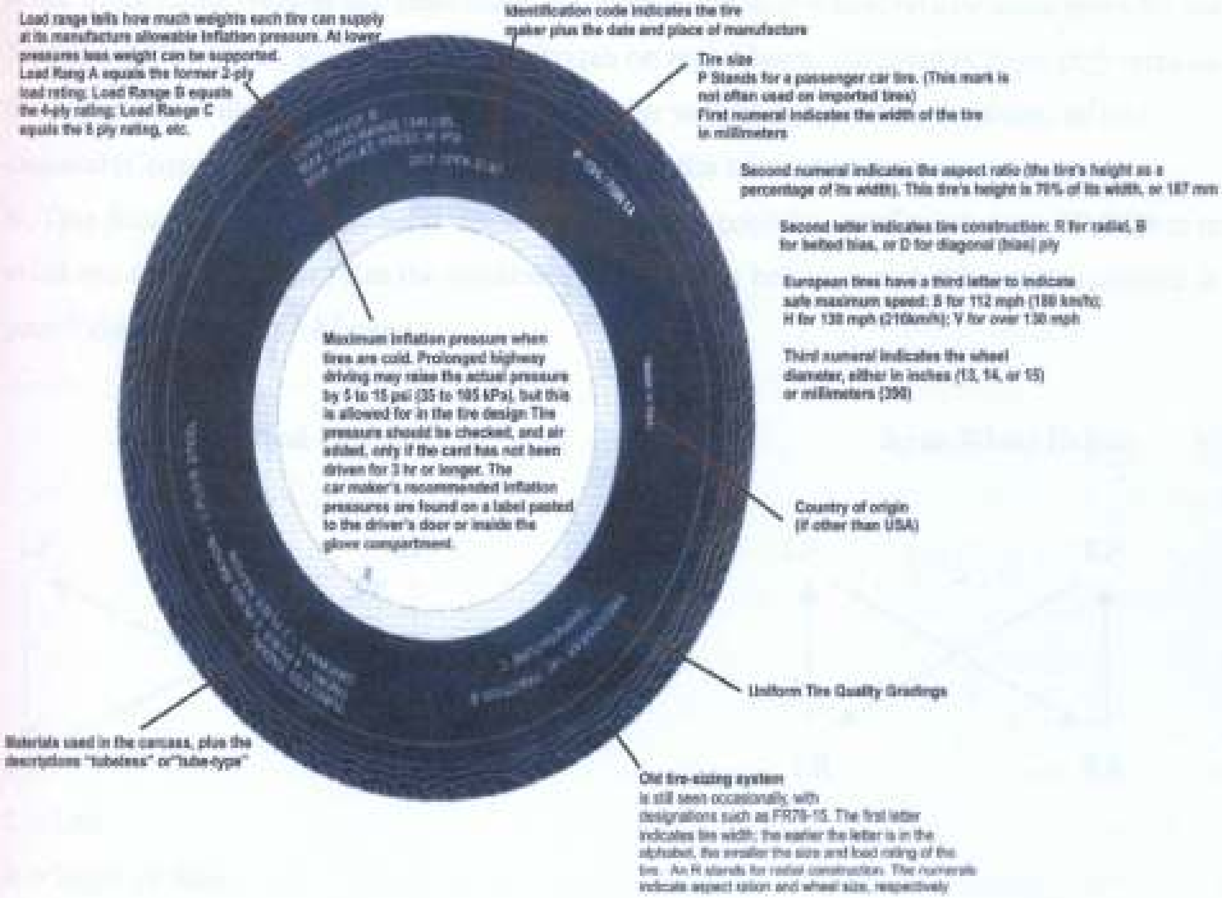


Figure 11: Tyre Markings
Source: Readers Digest Association (1981)

2.15 Tyre Maintenance

The most important factors promoting long tyre life are proper balance, wheel alignment, and inflation. No tyre or wheel is completely round or uniform. Each has heavy spots which can cause annoying vibrations at high speeds, as well as abnormal tyre wear. The wheels and tyres should be dynamically balanced, which involves spinning the wheel and tyre with a special machine to identify the heavy spots, then crimping lead weight to the rim to compensate for them. The amount of air pressure in a tyre affects not only how fast the tyre will wear but also the stability of the car and how much fuel it consumes.

Olagunju (2002), highlighted some tyre safety precautions as:

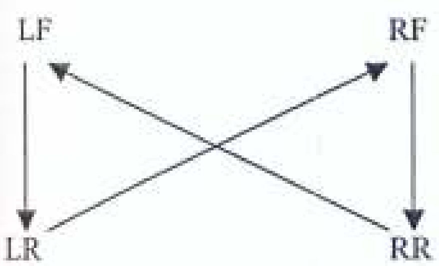
i. Tubeless tyres must only be fitted on rims specifically designed for the purpose.

ii. Storage and Expiration: Tyres should be stored in cool and dry conditions, out of direct sunlight and electrical generating equipment. Tyres should not be stored where they can absorb moisture to prevent tyre failure. An average tyre has 5 years life span. The week of manufacturing is also indicated on the tyres, e.g. 2598 means week 25 of 1998.

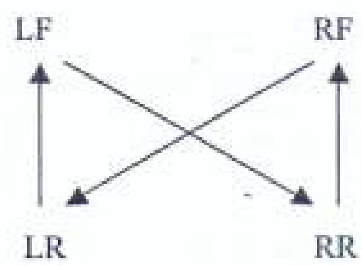
iii. Mixture of Radial and Diagonal/ Cross (X-ply)Tyres.: There are legal restrictions on this. It is better to fix radial tyres of the same make and type on all four-wheel tyre or same tyres for the X-ply tyres. However, you can have radial tyres on rear wheels, diagonal (Cross- ply) tyres on front wheel. It is illegal to fix diagonal tyres on rear with radial tyres on the front, or one diagonal (Cross- ply) tyre and one radial ply tyre on the same axle.

iv. Tyre Rotation.: Tyres can wear unevenly, hence the need for rotation at every 10,000km to avoid any abnormal wear. Use the rotational arrangement below except otherwise indicated in your Vehicle's Owners' Manual.

Front-Wheel Drive.



Rear-Wheel Drive.



L = Left.

R = Right or Rear.

F = Front.

v. Wheel Alignment: Tyres require wheel alignment, when you observe rapid and uneven tread wear, vibration of steering wheel, difficulty in turning steering wheel or steering wheel pulling to left or right.

vi. Correct Inflation: Under-inflation could result in rapid wears of the side wall. Over- inflation causes fast wear at the center of the tread region. Both affect the comfort and safety and life span of the tyre. The manufacturers recommended Pound per Square Inch (PSI) tyre pressure and the right gauge should be used. Check tyre pressure when tyres are cold at least once in a month.

vii. Inspection of Tyres: As tyre is that only contact the vehicle has with the earth surface, let the contacts be safe. Inspect tyres regularly. Also know that bad tyre condition and harsh driving affects fuel consumption, safety and comfort.

2.16 Tyres in the Environment

The U.S. Environment Protection Agency (1993) reported that an estimated 3 billion tyres as being tossed into the US dumps and landfills, creating monumental environmental problems. They are unsightly; the water they collect inside them harbours mosquito larvae; and, if they catch fire they release quantities of hazardous substances, and toxic chemicals are released, leaving an oily residue that can contaminate ground water. The environmentally-friendly tyre continues to be an industry concern. Tyre Collection Services has been committed to a professional strategy of offering a full solution to outlets. The huge increase of tyres being manufactured coupled with the rapid expansion of fast-fit centers has led to local authority land quickly becoming exhausted.

In many cases, tyres have found their way into rivers, canals and fields. It has become obvious for all concerned that controls needed to be put in place. Controls came in the form of government legislation relating to the disposal of used tyres under the Environmental Protection Act. Duty of Care Requirements, a registered company, approved by the local environmental agency in U.K, was mandated to collect all used tyres. In Nigeria, the responsibility of regulating or ensuring tyres standard falls under the control of the Standard Organisation of Nigeria and the Federal Customs Service, while vehicle tyre safety and maintenance falls under the control of the Federal Road Safety Corps. Several methods for their safe elimination were being tried in the mid 1990's.

The EU Landfill Directive (Table 2.2) will ban the disposal of tyres to landfill. In brief, whole tyres will be banned from July 2003 and shredded tyres from July 2006. The ban applies to almost all tyres including car, commercial, motorbike, aircraft, and industrial (including solid tyres).

However, bicycle tyres will not be subject to the ban, nor will tyres above 1.4 metres outside diameter (e.g. larger agricultural and earthmover tyres). In addition, the use of whole tyres in landfill engineering applications will be allowed to continue (Bryan, 1999).

From the early 1990's, there were discussions in Europe on the banning of tyres from disposal to landfill, thereby requiring their recovery. The tyre ban was subsequently incorporated in the EU Landfill Directive which was published in the Official Journal of the European Communities on 16 July 1999 as Council Directive 1999/31/EC of 26 April 1999 on the landfill of waste.

Table 2.2: EU Landfill Directive on Ban for Disposal of Used Tyres

Banned waste	New landfill sites	Existing hazardous sites	Existing non-hazardous sites	Existing inert sites
Whole used tyres	July 2003	July 2003	July 2003[1]	July 2003[1]
Shredded tyres	July 2004 (hazardous) July 2006 (non-hazardous/inert)	July 2004[2]	July 2006[1]	July 2006[1]

Source: Bryan (1999)

[1]For an individual site, the ban will come into effect when the site receives a Pollution Prevention and Control (PPC) permit but no sooner than July 2003 (whole tyres) July 2006 (Shredded tyres)

[2] A hazardous waste site can only accept hazardous waste after July 2004. Tyres are not hazardous waste.

2.17 Retreaded Tyres

The only part of a tyre to wear away in normal use is the tread and it makes both economic and ecological sense to give a new lease of life to an otherwise good tyre by what is now generally known as retreading. Retreading gives tyres with a worn out tread a new lease of life by applying new tread rubber onto the casing. This can be repeated several times as long as the casing is sound. Retreads are absolutely safe. They are extensively used in US, Europe and other advanced economies. In these economies, retreads are used on School Buses, Police cars, racing cars, emergency vehicles, trucks and Military vehicles. Retreads can be used on all sizes of tyres ranging from car tyres, Jeep tyres, Lorry tyres, bus tyres, heavy truck and trailers up to aircraft tyres. In most countries, including the advance European and US economies, most transport tyres are retreaded. In fact over 90% of the world airlines use retreaded tyres.

According to UK Department of Transport (2003), all retread tyres supplied in the United Kingdom must comply with the British Standard for retreaded tyres, BS AU 144e, and must be marked with the Standard Number (certain foreign made tyres may be acceptable if of an equivalent standard).

The penalties for offences related to the use of faulty tyres on vehicles are very severe. In case of any vehicle, except goods vehicles and vehicles adapted to carry more than eight passengers, for every offence there is a fine at level 4 of the standard scale with discretionary disqualification and compulsory driving license endorsement with 3 penalty points. Level 4 is currently £2500 and each faulty tyre is considered as a separate offence. Two faulty tyres equal £5000.

Offences can relate to:

1. Tread Depth: A tyre worn below the legal minimum.
2. Mixing: An incorrect mixture of radial and cross ply tyres.
3. Inflation: A tyre not inflated to make it suitable for the purpose to which the motor vehicle or trailer is being put.
4. Cuts: Certain long and deep cuts as specified in the regulations.
5. Lumps, bulges or tears: Caused by separation or partial failure of the tyre structure.
6. Exposed ply or cord

The British Standard requires strict examination and inspection of retreaded tyres at all stages and they must meet the same load / speed performance standards as new tyres. The tyre debris, often seen at the roadside, does not necessarily come from retreaded tyres. Retreaded tyres are used extensively on aircraft and in motoring competition.

2.18 Tyre Wheels

Figure 12 shows a car wheel. Road wheels support the vehicle's tyre as the car rolls down the road. Wheel must be able to withstand the considerable loads generated from acceleration, braking and cornering. Many regular passenger cars use steel wheels. Higher-performance machines and custom applications save unsparing weight by using wheels made from aluminium, magnesium, titanium or even space-age composite materials. In aftermarket circles, such performance wheels are often referred to as "mags," even if they're not made of magnesium.

The two basic parts of a wheel are the "spider," or the center-section that bolts to the vehicle's brake drum or rotor, and the rim -- the outer lips that contact and contain the tyre beads. On most wheels, the spider is a separate piece that is welded, riveted or bolted to the rim. Some custom wheels are cast in one piece or machined out of a single piece of solid billet-aluminium stock.

Passenger cars and light trucks use a "drop-center" wheel design, where the center of the wheel is of a smaller diameter than the edges. Such a configuration simplifies tyre installation and removal. With a deflated tyre, it allows one bead to fall easily into the "dropped" center-section, while the opposite bead is mechanically fitted over one of the rims. Most modern wheels add a safety ridge, which are small lips that keep the tyre on the rim in the event of a flat or a blowout.

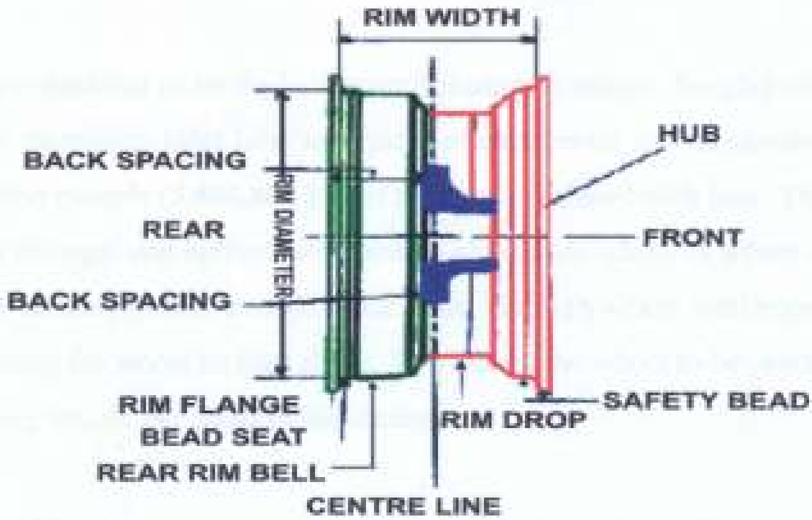


Figure 12: A Pictorial view of a Car Wheel
Source: Hodgson (2001)

2.18.1 Wheel Weights

Wheel weights are used to balance a wheel-and-tyre combination properly. The weights usually attach to the wheel by clipping onto the edge of the wheel or being affixed with double-sided tape. Correctly balanced wheels and tyres are critical, because when an unbalanced wheel revolves, centrifugal force acts on the heaviest portion of the wheel and tends to lift the tyre off the road, then slams it back down again during each revolution. This results in flat spots on the tyre tread and premature wear of suspension components. If a weight gets thrown off the wheel, the driver will likely be able to detect a vibration that's caused by an imbalance at high speeds, especially if the weight came off a front wheel.

2.18.2 Wheel Construction

There is a good variety of ways of constructing wheels. Most alloy wheels are made in one, two or three piece construction types. One piece is just what it says, a wheel made in a mould as a single piece. Two piece wheels are made of two separate pieces (center and barrel) that are usually welded or bolted together. Three piece wheels are made of three separate pieces. They have a center, and inside rim half, and an outside rim half. They are bolted together using the highest quality fasteners.

Manufacturing method is very important in the overall quality and performance of a wheel. Here are the most common types of manufacturing techniques employed:

1. **Forging**

Forging is considered to be the best manufacturing technique. Forging allows for the compression of an aluminium billet (one solid piece of aluminium) into an aluminium wheel using over 13 million pounds (5,896,800 kg) of pressure combined with heat. This produces a wheel that is both stronger and lighter than standard aluminium wheel. A subset of forging is called roll forging. In this process, a metal blank is run through rollers with impressions sunk in to their surface giving the wheel its final shape. This allows the wheel to be produced with less aluminium, reducing weight but maintaining strength.

2. **Low Pressure Casting**

This is the most common form of rim manufacturing. Much like a casting, liquid metal is poured into a mould and allowed to harden until the finished wheel is cool enough to be taken out of the casting.

3. Counter Pressure Casting

Opposite to low-pressure casting, the liquid metal is not poured; rather it is sucked into the mould using a vacuum. This reduces impurities making the wheel much stronger than a low pressure cast rim.

2.19 A Typical Roadside Tyre Removing and Fixing Tools/Implements

Figures 13 and 14 shows a typical roadside tyre bead breaking and tyre removing and fixing implements respectively. The former is used in breaking the bead of the tyre from the car rim while the later are used in removing or fixing the tyre from or into the car rim.

Figure 13: A Typical Roadside Tyre Bead Breaker

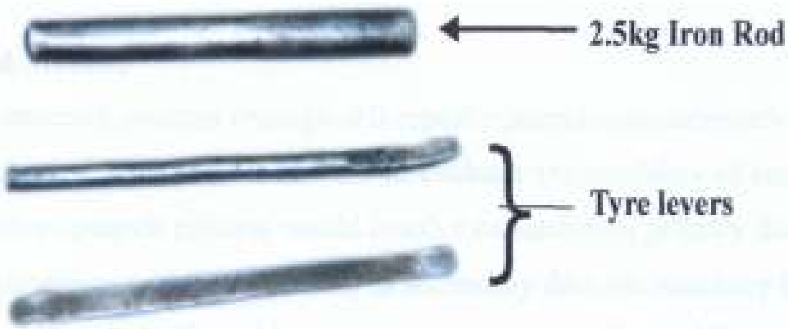


Figure 14: A Typical Roadside Tyre Removing/ Fixing Tools

2.20 A Typical Imported Tyre Removing/Fixing Machine

Figure 15 is an example of a typical imported tyre removing and fixing machine. This particular tyre removing / fixing machine is pneumatically controlled with an operating pressure of 10 bar, bead breaker roller pressure of 700N and weigh 48 kg.

Figure 15: A Typical Imported Tyre Removing/Fixing Machine
Source: Corghi Tyre Changer

CHAPTER THREE
RESEARCH METHODOLOGY

3.1 Materials and Method

Descriptive research process through self-report research and observation research method will be employed in this project in order to evaluate the reliability of automobile tyres. In this regard, descriptive research process would involve collection of primary data through the instrument of questionnaires and the collection of secondary data via statutory laws on tyre rules (safety) in the United Kingdom, United State of America and the Federal Republic of Nigeria.

The problems arising from the use of local/roadside vulcanizer's tools/ implements and imported tyre removing/fixing machines were examined. Their shortcomings are:

3.1.1 Problems Encountered by Roadside Vulcanizers.

- The heavy metal rod used in removing the tyre bead from the rim causes lots of damages to the tyre bead due to the heavy punches inflicted on the tyre bead.
- When fixing the tyre into the rim, the same heavy metal rod is used in forcing the tyre bead into the rim. In this process, the tyre bead is subjected to tears and wears which cause un-even grip of the tyre bead on the tyre rim.
- All operations are manually done and are directly or indirectly dependent on the operator's strength. Fatigue is not ruled out.
- Since all these operations are performed on the ground, sand and other solid particles often enter the tyre assembly during the fitting of the tube and or tyre back into the rim.

3.1.2 Problems Encountered in the Use Of Modern Tyre Removing Equipment by Big Organisations.

- These machines are sophisticated in design, construction and operation, as well as their repairs and maintenance.
- Their cost of production and maintenance is high, thus out of reach of the common man (least price is ₦750, 000: 00).
- There are heavy and cannot be carried about.
- Most of the component parts are not available locally.

An improved local tyre removing/fixing device was designed and developed. Tests were carried out on it and its workability as ascertained.

Sequel to the administration of questionnaires, oral interviews were conducted among tyre users, sellers and agencies responsible for tyre standard, rules and regulation in Nigeria notable among are: The Standards Organisation of Nigeria, Federal Road Safety Corps and The Nigeria Customs Service.

These questionnaires were presented and explained. The results were expressed in percentage rates for easy and clear analysis. Coupled with the oral interviews, finding were drawn from the analysis which enabled an evaluation or assessment of the researcher to arrive at reasonable conclusion and to identify the understanding of tyre users and sellers on tyre safety and maintenance, the legal implication of using second-hand tyres and proffer a simple test on what to look out for when buying a second-hand tyre.

3.2 Collection Of Primary Data

The primary data were collected through questionnaire survey and oral interview. The questionnaires were administered on tyre users, tyre sellers /vulcanizers, students, personnel of the Federal Road Safety Corps, Nigeria Police Force, Standards Organisation of Nigeria, Nigeria Customs Service, Lagos State Road Management Agency, e.t.c in the form shown in Appendix1. The questionnaires were structured in a way for easy assessment or evaluation of how knowledgeable Nigerians are on tyres, its safety and maintenance.

80 questionnaires were administered while 72 were returned representing 90 % rate of response (Table 3.1). Arising from the responses to the questionnaires, an oral interview was conducted among tyres users and sellers and government agencies that have one or two things to do with tyres and its usage. The reason is to find out what are the statutory laws guiding tyres in this country. Also witnessed was the examination of the importation of used tyres by men of the Nigeria Custom Service and Standards Organisation of Nigeria at the Nigeria Ports Authority, Lagos.

Table 3.0 shows the frequency distribution of variables used in the primary data showing the level of responses given to each question asked.

TABLE 3.0 Frequency Distribution Of Variables Used In Primary Data

3.1 Number of Questionnaires Administered

Respondent	Frequency	Percentage
Returned	72	90
Not Returned	8	10

3.2 Categorisation of Tyre Handler

Respondent	Frequency	Percentage
User	40	56
Seller	10	14
User & Seller	15	20
None of the above	7	10

3.3 Academic Qualification of Respondents

Respondent	Frequency	Percentage
WASC/GCE	18	25
City & Guild	16	23
ND	10	14
HND	7	9
B.Sc	7	9
M.Sc	5	7
PhD	0	0
Others	9	13

3.4 Types of Tyres

Respondent	Frequency	Percentage
Radial	43	59
Bias-ply	15	21
Belted-bias	4	6
I don't know	10	14

3.5 Types of Tyre wear

Respondent	Frequency	Percentage
One-sided wear	35	53
Center wear	20	31
Shoulder wear	1	1
Spot wear	0	0
Diagonal wear	0	0
Feather-edged wear	1	1
I don't know	9	14

3.6 Gauging of Tyre Pressure

Respondent	Frequency	Percentage
Bi-monthly	8	13
Monthly	16	25
When I notice that the tyre is flat	40	62

3.7 Effect of Tyre Pressure on Fuel Consumption

Respondent	Frequency	Percentage
More fuel consumption	28	42
Less fuel consumption	24	36
I don't know	15	22

3.8 State of Checking Tyre Pressure

Respondent	Frequency	Percentage
Cold	26	41
Hot	13	20
I don't know	25	39

3.9 When should an automobile wheel be aligned?

Respondent	Frequency	Percentage
Weekly	0	0
Monthly	19	30
When I notice that the vehicle does not keep to a straight path while driving	44	70

3.10 Definition of Part-worn Tyre

Respondent	Frequency	Percentage
The tyre tread depth is not below 1.66mm	10	15
The tyre tread channel is 2/32nd of an inch	3	5
A tyre tread depth is completely missing	12	19
I don't know	39	61

3.11 Effect of Worn-out Tyre on an Automobile

Respondent		Frequency	Percentage
a	The braking system of the car becomes less effective	21	34
b	Steering becomes difficult	7	11
c	Acceleration is hard	0	0
d	a & b	12	20
e	a & c	3	5
f	b & c	3	5
g	a, b & c	9	14
h	I notice nothing	7	11

3.12 Definition of Retreaded Tyre

Respondent	Frequency	Percentage
The tyre tread had been replaced	35	55
A tyre with tread depth below 1.6mm	0	0
I don't know	29	45

3.13 Use of Retreaded Tyres

Respondent	Frequency	Percentage
Yes	15	25
No	45	75

3.14 Effect of Using Retreaded Tyres

Respondent	Frequency	Percentage
Tyre tread chipped off easily	5	33
Frequent tyre puncture	8	53
Tyre unstable in use	1	7
I notice nothing	1	7

3.15 Method of Checking Tyre Tread Depth

Respondent	Frequency	Percentage
Lincoln's penny method	1	2
Using tyre wear indicator	7	10
Visual Inspection	45	66
I don't know	15	22

3.16 Effect of Sudden Application of Brake on Automobile Tyres

Respondent	Frequency	Percentage
The tyre skids	18	26
The tyre tread wears	23	33
The tyre surfaces develop flat and bald spots	5	8
I notice nothing	23	33

3.17 Automobile Tyres should be rotated?

Respondent	Frequency	Percentage
Yes	35	49
No	37	51

3.18 Reason(s) for Rotating Automobile Tyre

a. Front tyres wear faster.

b. To prevent excessive tyre wear.

c. A rotation of the tyres is done occasionally by my vulcanizer while patching my tyres and according to him is to reduce tyre wears.

3.19 Reason(s) for not Rotating Automobile Tyre

a. I don't know the importance.

b. I don't have a car.

3.20 Proper Sequence of Rotating Tyre(s) is?

Respondent	Frequency	Percentage
Front to Rear	26	44
Side to Side	33	56

3.21 I change damaged Tyre(s) for New

Respondent	Frequency	Percentage
Yes	28	41
No	40	59

3.22 Reason(s) for buying new tyres

a. New tyres are more reliable, efficient and safe.
b. New tyres last longer and have good tyre tread.
c. The quality of new tyres is guaranteed.
d. New tyres are durable and safe.
e. Second-hand tyres are likely to have frequent puncture.

3.23 Reason(s) for buying Second-hand or Tokunbo Tyres

a. New tyres are expensive and out of the reach of the poor.
b. Tokunbo tyres are economical and durable.
c. I sell second-hand tyres, which I believe are better than made in Nigeria tyres.

3.24 The Legal Minimum Requirement of Tyre Tread Depth is?

Respondent	Frequency	Percentage
1.66mm	15	21
1/6th of an inch	5	7
I don't know	50	72

3.25 Which of the following Organisations is responsible for ensuring Quality Control(Standard) of Tyre in Nigeria?

Respondent	Frequency	Percentage
Nigeria Customs Service	7	10
Federal Road Safety Corps	32	46
Standards Organisation of Nigeria	28	41
National Agency for Food, Drug and Administration and Control	2	3

3.26 Where do you repair your tyres?

Respondent	Frequency	Percentage
Roadside/Local Vulcanizer	58	79
Mechanised Workshop	15	21

3.27 How are your tyres removed?

Respondent	Frequency	Percentage
By use of Local Tools	55	73
By use of Industrial Machines	20	27

3.28 Which one in your Opinion Prolongs the Life of Tyres?

Respondent	Frequency	Percentage
Local Tools	10	15
Instruments used by mechanized machines	30	46
I don't know	25	39

3.29 Can the local way of removing/fixing tyres be improved upon?

Respondent	Frequency	Percentage
Yes	50	83
No	10	17

3.30 If yes, any suggestion?

1. Higher Institution of learning in Nigeria should research into ways of improving local tools used in tyre removal and fixing operations.
2. Foreign made tyre machines should be copied and localised.
3. Foreign technology on tyre removing device should be copied or stolen.

3.3 Collection of the Secondary Data

The secondary data were the examination of the statutory laws on tyres in Nigeria and other countries like United States of America and United Kingdom. These are shown in Appendices 6, 7, 8 and 9. The secondary data are:

1 Motor Vehicle Tyres (Safety) regulations 1994 in UK (Appendix 6).

2 US Department of Transportation, Office of Public Affairs, "Many US Passenger Cars are driven on Bald tires", NHSTA research shows (Appendix 7).

3 UK Tyre Laws (Appendix 8).

4 Standards On New Pneumatic Passenger Car Tyres. Nigerian Industrial Standard NIS252: 1989, UDC: 621.54:629.113.0125 by Standards Organisation of Nigeria (Appendix 9).

3.4 THE EXPERIMENTAL MACHINE

The machine is principally based on the principle of power transmission by the use of bevel gear and pinion. It is an assembly of a channel frame which serves as the chassis of the device, a bead breaker, a bevel gear, a pinion, re-enforcement bar, mounting plate, remount/dismount tool, etc. The bevel gear and pinion were sourced from a gear box assembly of a used Volkswagen Paragon bus. It is a mechanical device simple to operate manually and easily maintained. It is an improvement over the local/roadside vulcanizer tyre removing/fixing device.

3.4.1 Description of the Machine

Figure 16 below shows the working principle of the machine, and Appendix 4 are the machine drawings of the manual tyre removing and fixing device.

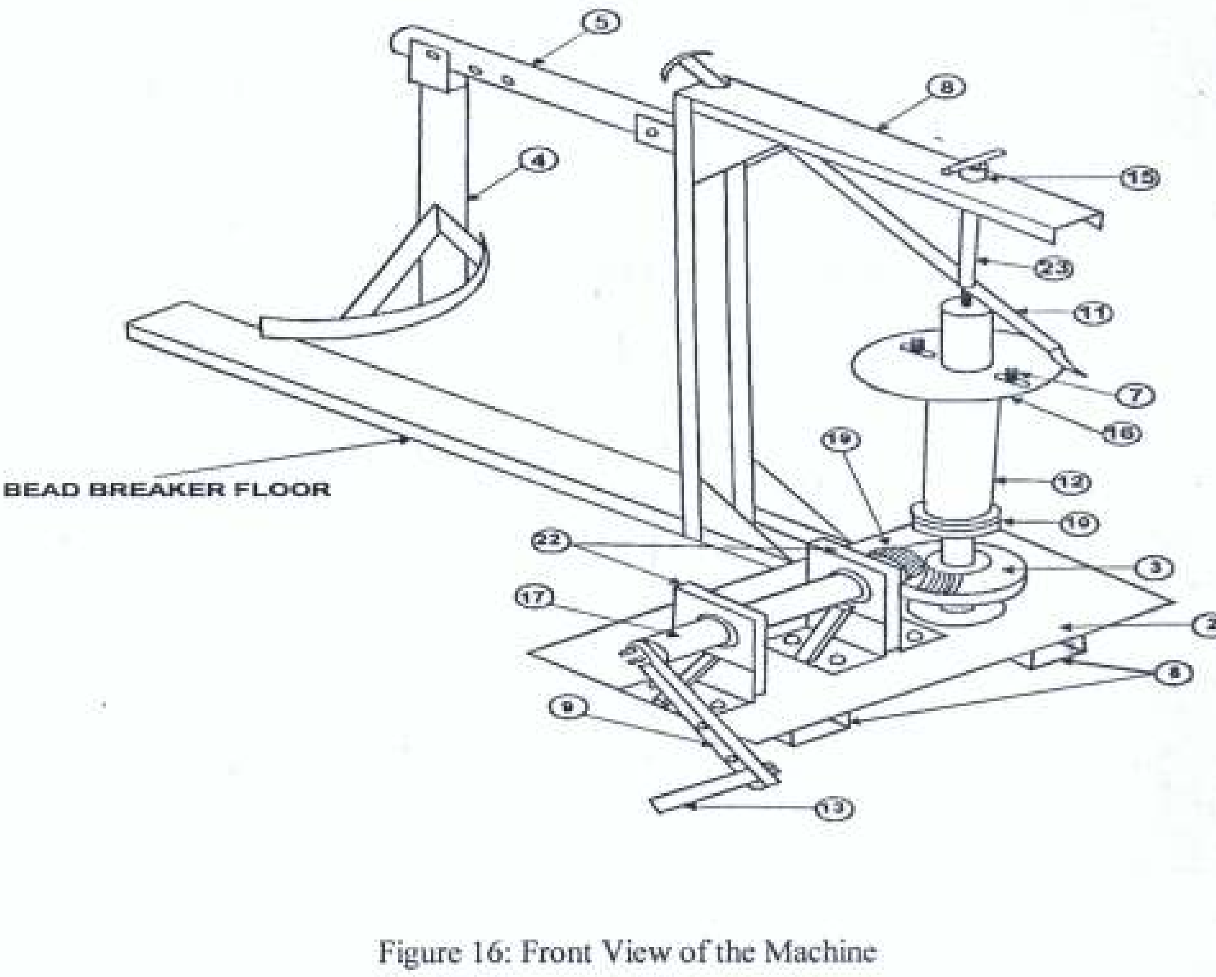


Figure 16: Front View of the Machine

The base plate (#2) is welded on top of the channel (#8) shaped like alphabet h which is the mainframe (chassis) of the device. Welded on the base plate is the bevel gear stand (#27) which sits the bevel gear (#3). The pinion shaft(#17) already welded to the pinion(#19) is aligned horizontally on the bevel gear passing through two steel bushing(#21) inside two reinforcement bars(#22) that are bolted(#7) on the base plate. The crank arm (#9) is fixed to the end of the pinion shaft using two bolts (#6) and on its end the handle (#13) is connected. A coupling (#10) connects the driven shaft (#12) to the bevel gear which also has the mounting plate (#16) welded at a pre-determined position. The driven shaft and the mounting plate are a two- piece off units which are detachable to accommodate a 2 or 4 plug hole car rim or a 5 plug hole car rim as the case may be. The tyre assembly to be worked on sits on the mounting plate and is locked in position by two bolts (#7). On the vertical side of the channel has the bead breaker handle (#5) attached by bolt (not shown) and on its end stands the bead breaker (#4). Welded to the top of the horizontal side of the channel is a lock arm locator (#15) where the lock arm (#23) passes to lock firmly the remount/dismount tool (#11) on the tyre assembly bolted to the mounting plate. A slot is made on the top of the vertical channel where the remount/dismount tool passes. The interface between the bevel gear and the pinion is greased to reduce friction and this portion is enclosed in a housing box (#14) to prevent dirt and dust coming in contact with the interface.

3.4.2 Operation of the Machine

3.4.2.1 Bead Breaking

Step 1: Remove the air from the tyre assembly. For best results remove the tyre's value core.

Step 2: Place the tyre and wheel assembly on the bead breaker floor.

Note: Place first the tyre side having the valve. After the breaking the bead of this side, the tyre is reversed to break of bead of the other side.

Step 3: Position the bead breaker so that its shoe is touching the edge of the tyre's rim (Figure17).

Step 4: Firmly apply pressure to the bead breaker by pushing down on the long handle of the bead breaker.

Step 5: When the first bead is completely loosened, turn the tyre assembly and repeat the procedure for the opposite side of the tyre.

Figure 17: Tyre Bead Breaking Operation

3.4.2.2 Removing the Tyre Upper Bead from the Car Rim

Step 1: Lubricate both sides of the tyre beads. Coat each bead liberally with soapy water to ensure that the tyre bead will slide easily over the rim.

Step 2: Mount the tyre assembly with the side having the valve on the manual tyre removing and fixing device on the mounting plate and bolt down.

Step 3: Lift a little portion of the tyre bead with a tyre lever and slide in the dismounting end of the remount/dismount tool so that the tyre bead rests on the dismounting end of the tool (Figure 18).

Step 4: Lock the remount/dismount tool with the lock arm to prevent the tool from pulling off from the tyre assembly while in operation.

Step 5: Turn the handle of the crank arm of the tyre removing device clockwise to rotate the pinion and the bevel gear. This causes the driven shaft to rotate the mounting plate and in the process removing the tyre bead from the tyre assembly.

3.4.2.3 Removing the Tyre Lower Bead from the Car Rim

With the tyre assembly still firmly secured on the mounting plate, the process of removing the lower bead of the tyre from the car rim begins

Step 1: Raise the tyre so that the lower bead is just under the upper lip of the rim.

Step 2: Repeat steps 3 and 4 as in removing the tyre upper bead from the car rim above.

Step 3: Repeat step 5 above to completely remove the tyre bead from the car rim for further repairs.

Figure 18: Tyre Removing Operation

WARNING: Failure to use bead lubricant e.g. soapy water when removing the tyre from the rim may result in damage to the bead.

3.4.2.4 Installing the Tyre Lower Bead on Car Rim

Step 1: To mount a new or repaired tyre, first lubricate the inside and outside of both sides of the tyre bead.

Step 2: Position the car rim on the mounting plate and firmly secure it in position.

Step 3: Push the lower bead of the tyre onto the rim as far as it as it will go without forcing it.

Step 4: Place the remount end of the remount/dismount tool through the slot on the vertical channel over the tyre bead (Figure19).

Step 5: Place the remount end of the re/dismount tool against the outside edge of the rim pressing the tyre bead in on the opposite side of the tyre that is yet to enter the rim (after step 3 operation).

Step 6: Turn the crank arm handle clockwise. This will force the remaining tyre bead over the rim's upper edge.

Step 7: Using a mallet, tap the tyre bead that had enter into the rim to drop the bead below the drop center of the rim in order to make room for the rest of the tyre bead to enter into the tyre rim while since carrying out operation 6 above.

3.3.2.5 Installing the Tyre Upper Bead on Car Rim

Once the lower bead is completely over the edge of the rim, you can install the upper bead.

Step 1: Repeat steps 3, 4, 5 and 6 as in fixing the lower tyre bead above.

Step 2: Remove the remount/dismount tool when the tyre has been fixed into the car rim.

Figure 19: Tyre Fixing Operation

CHAPTER FOUR
RESULTS AND DISCUSSION

4.1 Deduction from Primary Data

Table 3.0 shows the frequency distribution of variables used in the primary data and with the oral interview conducted reveals the following:

1. Table 3.1 shows that 80 questionnaires were administered. 72 or 90% of the questionnaires were returned. This shows that the result obtained from the analysis, which will be carried out, will be good or at least fair since more than 50% of the questionnaires administered were returned (Figure 20).

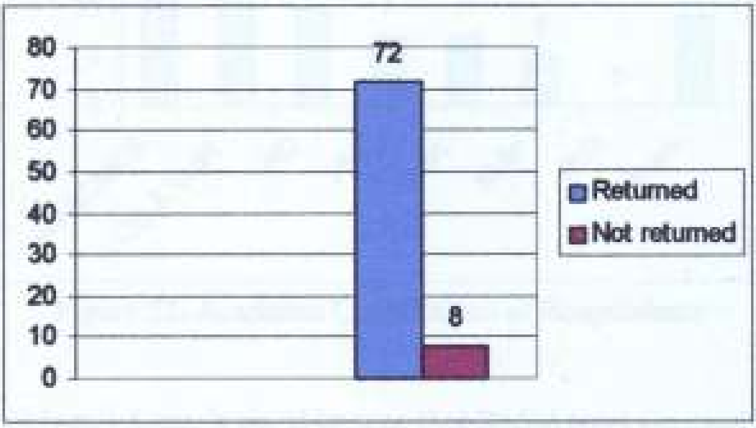


Figure 20: Number of Questionnaires Administered

2. The analysis of Table 3.2 is to determine if the respondents were tyre users, sellers or both. Figure 21 shows that 56%(40) of the respondents are tyre users, 14%(10) are sellers, 20%(15) are both users and sellers while 10%(7) believed that they have nothing to do with automobile tyres. Unfortunately, this is not true as movement of goods or people are mostly done through vehicular transportation which involve the use of tyres as a component part of the vehicle.

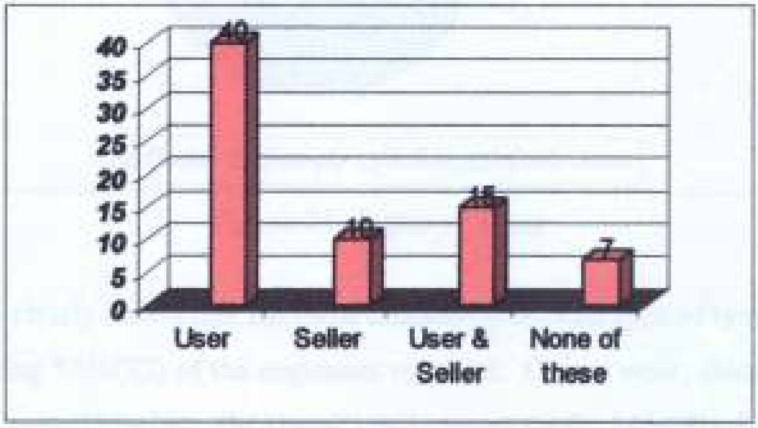


Figure 21: Categorisation of Tyre Handlers

3. The analysis of Table 3.3 is the determination of the educational level of the respondent's vis-à-vis their knowledge on tyres. 25%(18) of the respondents were School Certificate holders, 23%(16) were City & Guild Diploma holders; 14%(10) and 9%(7) were National Diploma and Higher National Diploma holders respectively. Bachelor of Science and Doctoral degree holders are 9%(7) and 0%(0) respectively. 13%(9) of the respondents failed to indicate their level of education (Figure 22). Thus it could be assumed that all level of education was considered in this evaluation.

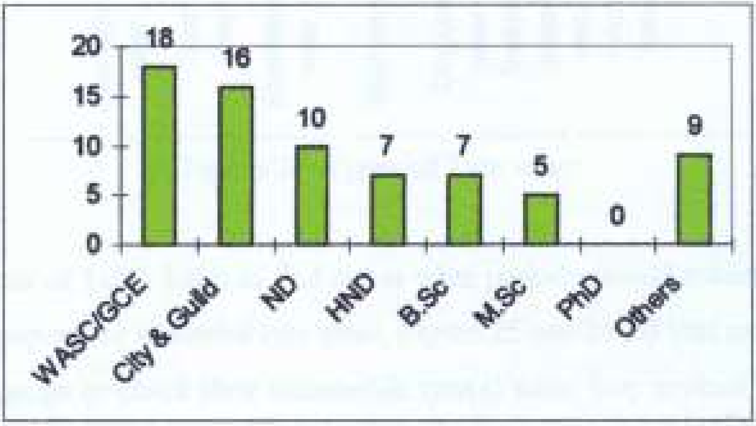


Figure 22: Academic Qualification of Respondents

4. In the survey carried out, it could be seen that Radial tyres are mostly used by the respondents which represent 59% of responses received . 21% and 6% of the respondents are familiar with Bias-ply and Belted-bias tyres respectively. Due to ignorance, 14% could not identify the type of tyres in use (Figure 23).

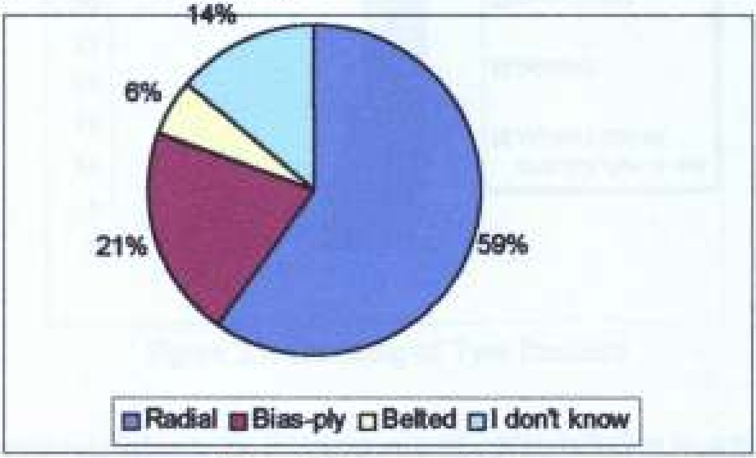


Figure 23: Types of Tyres

5. Figure 24 clearly shows that the most commonly noticed type of tyre wear is one-sided tyre wear, representing 53%(32) of the responses received. Center wear, shoulders wear and feather-edged wear were 31%(20), 1%(1) and 1%(1) respectively. 14%(9) of the respondents

could not identify any type of tyre wear while spot wear or diagonal wear are unknown to the respondents.

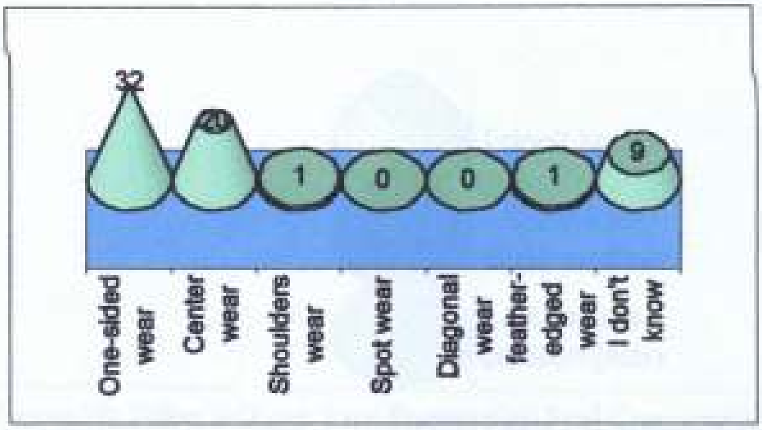


Figure 24: Types of Tyre wear

6. The analysis of Table 3.6 is to find out at what periods should automobile tyre is best gauged in order to prevent or minimize tyre wear. Figure 25 confirmed that most motorists, 62% of the respondents gauge or check their automobile tyre(s) when they noticed that the tyre(s) is flat or bulge at the side. 13% and 25% of the respondents check tyre pressure bi-monthly and monthly respectively. Thus it could be deduced that the concept of regular tyre pressure check is absent among the respondents.

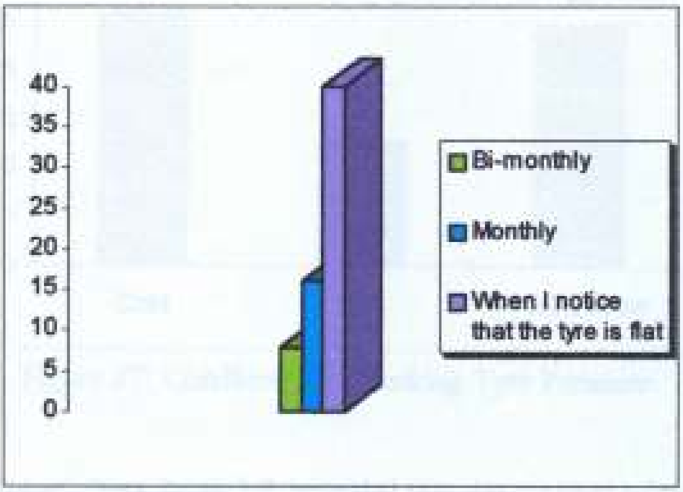


Figure 25: Checking of Tyre Pressure

7. In the survey carried out, the consequence of under-inflation to automobile tyre(s) to fuel consumption is relatively unknown. Figure 26 shows that 42%(28) of the respondents believe that low tyre pressure can increase fuel consumption while 36%(24) think otherwise with 22%(15) having no idea about this.

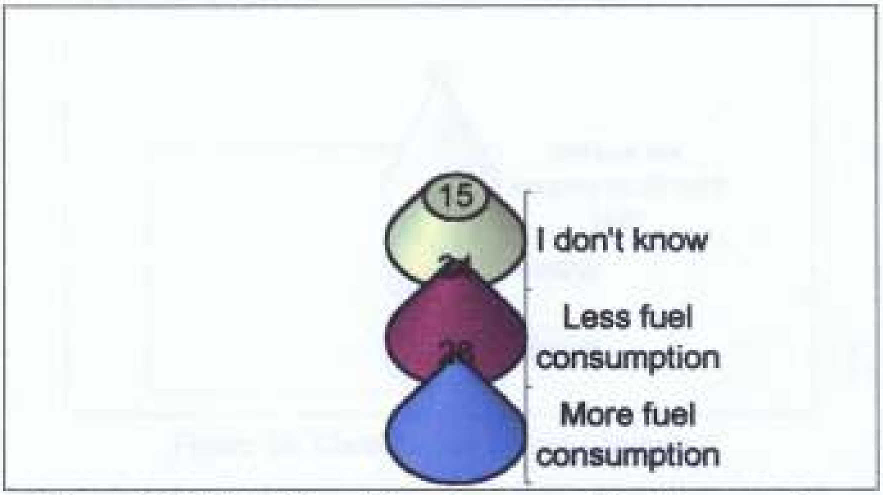


Figure 26: Effect of Low Tyre Pressure on Fuel Consumption

8. The analysis of Table 3.8 is to determine at what condition tyre(s) pressure is best checked. 41%(26) of the respondents believed that tyre pressure is best checked when the tyre(s) are cold, 20%(13) of the respondents are of the opinion that tyre is best check when hot i.e after travelling some distance. 39%(25) of the respondents have no idea when best to check for tyre pressure (Figure 27). However, tyre manufacturers advice that tyre pressure should be check and inflated in cold condition.

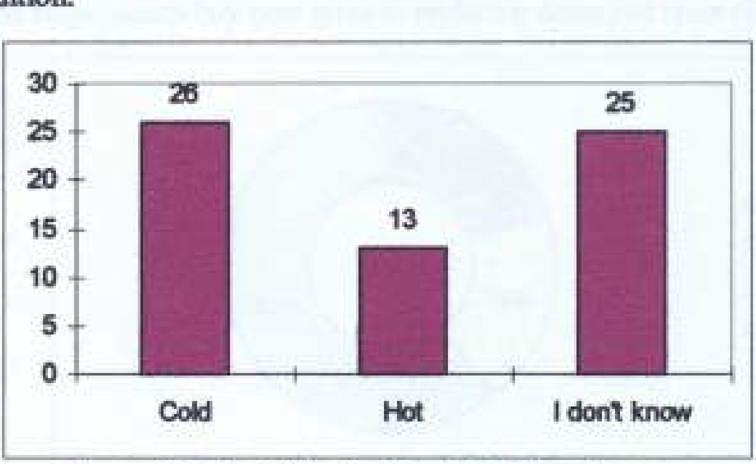


Figure 27: Condition for Checking Tyre Pressure

9. Figure 28 obtained from Table 3.9, revealed that the concept of regular wheel alignment is unknown among the respondents. 70%(44) of the respondents check their wheel alignment when they notice that their cars doe not keep to a straight path while driving. 0%(0) and 30%(19) of the respondents think alignment should be done on a weekly and monthly basis respectively

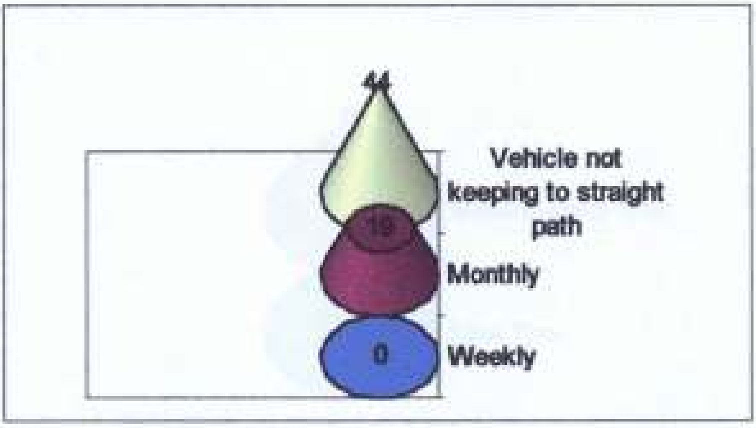


Figure 28: Checking for Wheel Alignment

10. The analysis of Table 3.10 is to know the respondents knowledge of the definition of part-worn tyre. 61%(50) of the respondents do not know what a part-worn tyre is, 19%(12) define it as a tyre with complete missing tyre tread depth. 5%(3) and 19%(12) of the respondents define part-worn tyre as one with a tyre tread depth channel of 2/32nd of an inch and tyre tread depth of not below 1.66mm respectively(Figure 29). However, Table 3.21 revealed that 59%(40) opt for second-hand tyres which otherwise are called part-worn tyres while replacing damaged tyres. 41%(28) of the respondents buy new tyres in replacing damaged tyres (Figure 30).

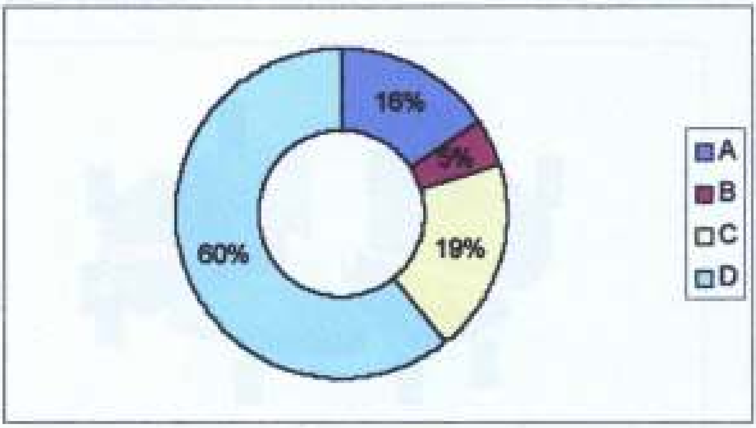


Figure 29: Definition of Part-worn Tyre

Note:

A = Tread depth not below 1.66mm
B = Tread depth channel is 2/32nd of an inch
C = Tread depth is completely missing
D = I don't know

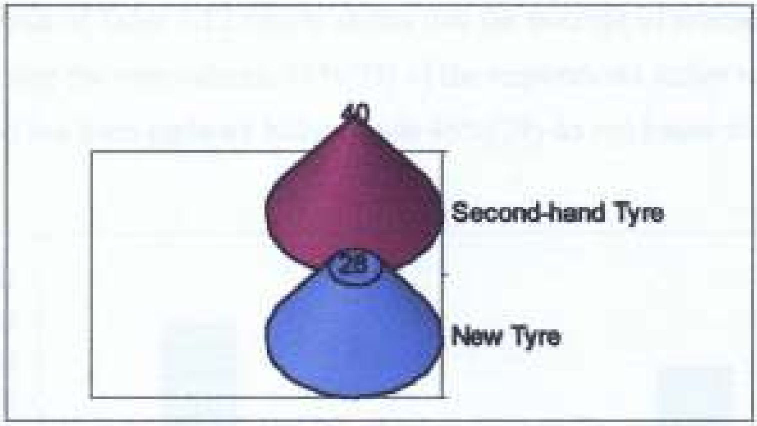


Figure 30: Decision to buy New or Second-hand Tyre

11. The ignorance of the respondents to the effect of worn-out tyres can be seen in Table 3.10. 34% of the respondents believe that the greatest danger of worn-out tyres is less effectiveness of the braking system. 11% feel that worn-out tyres make steering more difficult and 0% think that it has nothing to do with acceleration. 11% of the respondents have no idea of what the effect of worn out tyre is. Others believe in the combination of these as shown in Figure 31. However tyre manufacturers caution that worn-out tyres make steering difficult, acceleration hard and braking system less effective.

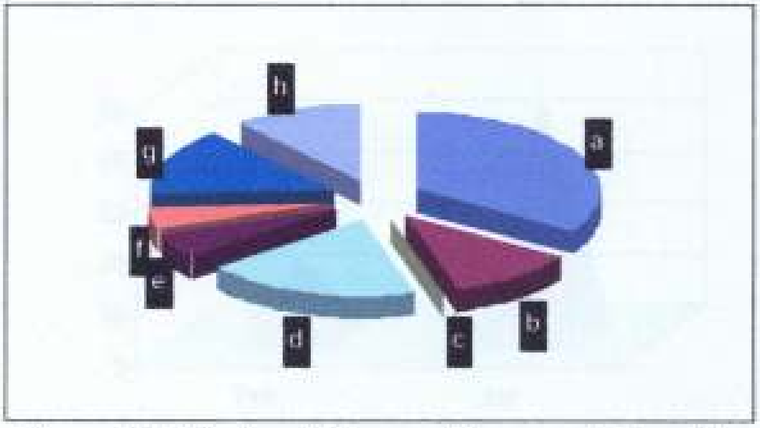


Figure 31: Effective of Worn-out Tyres on Automobile

Note:
a = The braking system of the car becomes less effective
b = Steering becomes difficult
c = Acceleration is hard
d = a & b
e = a & c
f = b & c
g = a, b & c

12. The analysis of Table 3.12 clearly shows that the concept of retreaded tyre is relatively known among the respondents. 55%(35) of the respondents define retreaded tyre as one whose tyre tread has been replaced before while 45%(29) do not know what retreaded tyre is (Figure 32).

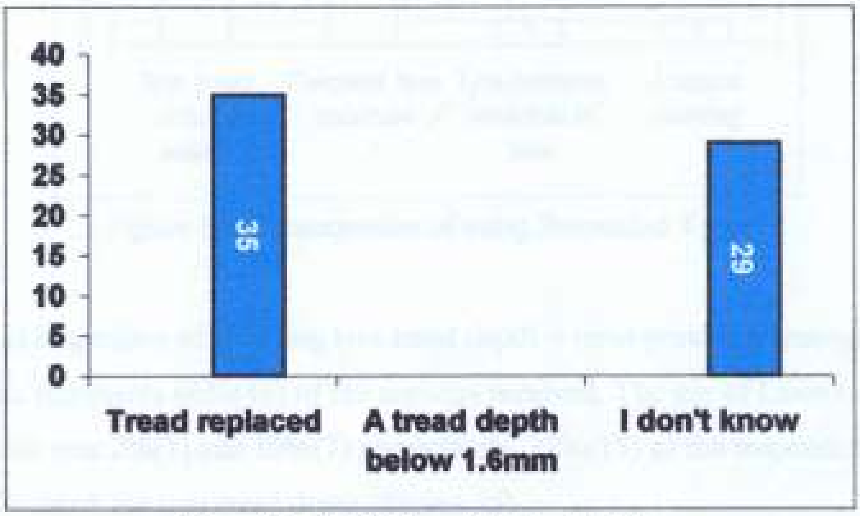


Figure 32: Definition of Retreaded Tyre

13. In the survey shown in Table 3.13, which has a correlation with Table 3.12 above, though the concept of retreading is known, 75% (45) of the respondents do not believe in its usage (Figure 33).

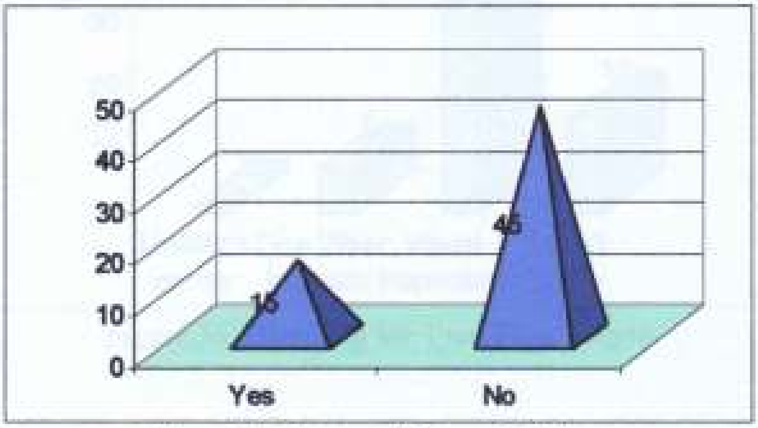


Figure 33: Usage of Retreaded Tyres

14. The analysis of Table 3.14 strengthens the belief in the none usage of retreaded tyres as 53%(8) of the respondents believes that retreaded tyres could lead to frequent tyre puncture. 33%(5) thinks that retreaded tyres tread chip off easily while 7%(1) are of the opinion that these tyres are not stable in use. 7%(1) of the respondents however do not notice any damage in the use of retreaded tyres (Figure 34).

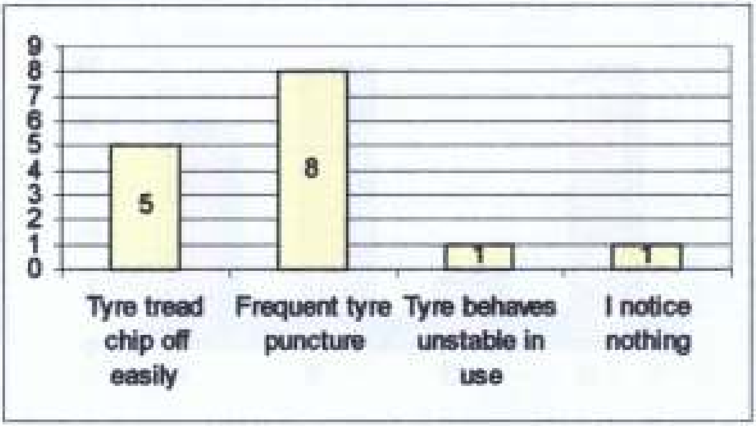


Figure 34: Consequence of using Retreaded Tyres

15. Visual Inspection of checking tyre tread depth is most prevalent among the respondents. This represents 66%(45) of the answers received. The use of Lincoln's penny and tyre wear indicator was 2%(1) and 10%(7) respectively. 22%(15) of the respondents however do not know how to check for tyre tread depth (Figure 35).

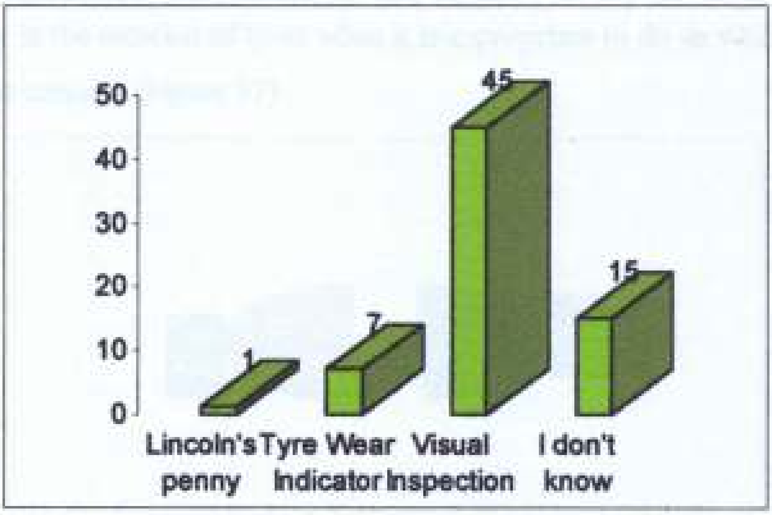


Figure 35: Checking for Tyre Tread Depth

16. Could sudden application of brake to automobile tyres have any effect on the tyres and what are these effects especially to second-hand tyres? 26%(18) of the respondents are of the opinion that sudden application of brake causes tyre to skid. 33%(23) of the respondents believe that sudden application of brake causes tyre to wear. 8%(5) of the respondents feels that the tyre surfaces develop flat and bald spots while 33%(23) notice nothing (Figure 36).

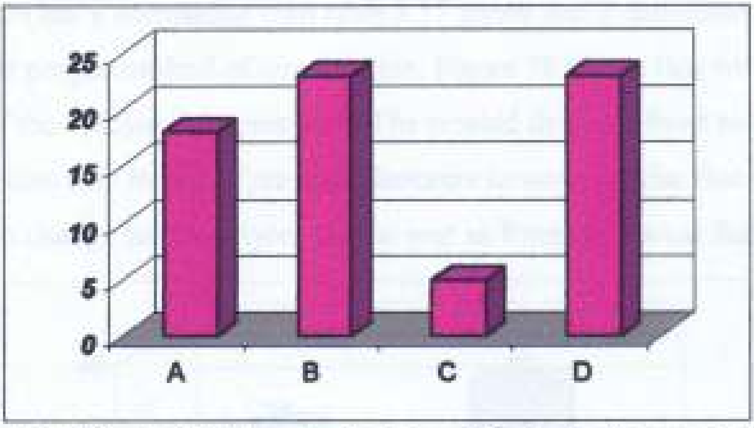


Figure 36: Effect of Sudden Application of Brake to Automobile Tyres

Note:
A = The tyre skid
B = The tyre tread wears
C = The tyre surfaces develops flat and bald spots
D = I notice nothing

17. The concept of tyre rotation as shown in Table 3.17 revealed that 49% of the respondents engage in the rotation of tyres when it is appropriate to do so while 51% are clearly not in tune with this concept (Figure 37)

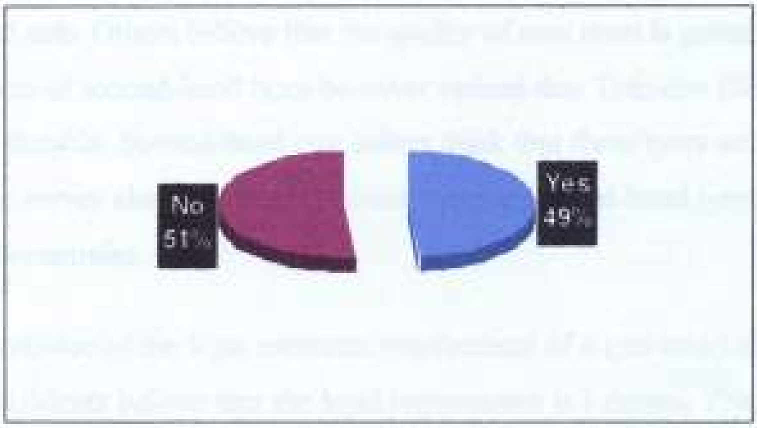


Figure 37: The Concept of Tyre Rotation

18. The analysis of Table 3.18 revealed that those who believe in the concept of tyre rotation do so to prevent excessive tyre wear especially for the front tyres while others succumb to the opinion of tyre repairers (vulcanizers) in doing so.

19. The analysis of Table 3.19 shows that ignorance is the main reason for those who do not rotate their tyres as the effect of this is unknown to them.

20. Table 3.20 has a correlation with table 3.17 above and it determines the respondent's knowledge about the proper method of tyre rotation. Figure 38 shows that 44% (26) of the respondents were of the opinion that tyres should be rotated from the front to the rear while 56%(33) think it is from side to side. Tyre manufacturers however advise that the best method for tyre rotation is to change the front tyres for the rear as front tyres wear faster.

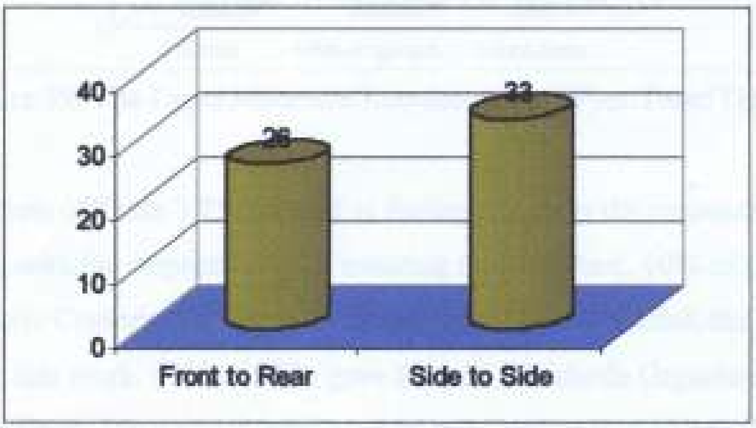


Figure 38: Sequence of Rotating Tyres

21. Tables 3.21 and 3.22 show the different perception of tyre users and sellers to new and second-hand (Tokunbo) tyres. Some of the tyre users believe that new tyres are more reliable, efficient and safe. Others believe that the quality of new tyres is guaranteed and that they last longer. Users of second-hand tyres however opined that Tokunbo (Second-hand) tyres are economical and durable. Second-hand tyre sellers think that these tyres are better than made in Nigeria tyres. The survey also revealed that most users of second-hand tyres opt for this because of financial constraint.

22. The description of the legal minimum requirement of a tyre tread depth shows that 21%(15) of the respondents believe that the legal requirement is 1.66mm. 7%(5) of the respondents think it is 1/6th of an inch while 72%(50) do not know what the minimum requirement is (Figure 39). In the UK and US, the legal minimum requirement of a tyre tread depth is put as at least1.66mm.

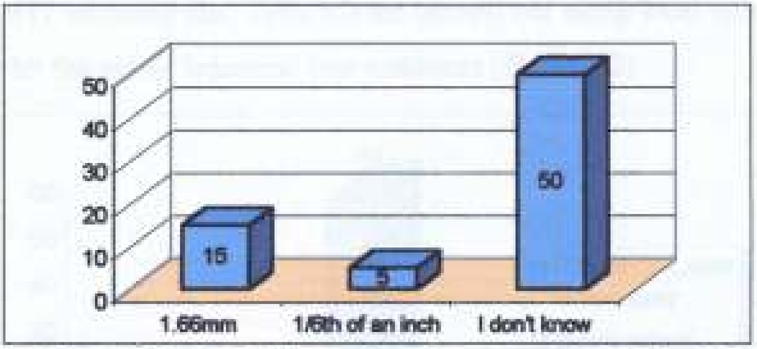


Figure 39: The Legal Minimum Requirement of Tyre Tread Depth

23. The analysis of Table 3.25 is aimed at finding out from the respondents which agency in Nigeria is saddled with the responsibility of ensuring tyre standard. 10% of the motorists believe that the Nigeria Customs Service has this responsibility. 46% think the Nigeria Road Safety Corps handle this work. 41% and 3% gave it to the Standards Organisation of Nigeria and National Agency for Food, Drug and Administration and Control respectively (Figure 40). The conclusion from this survey is that most motorists are not fully aware of which agency is responsible for the quality control of tyres in Nigeria. There is a mix up between quality control (standard) and safety rules and regulations among the motorist and tyre sellers and users interviewed.

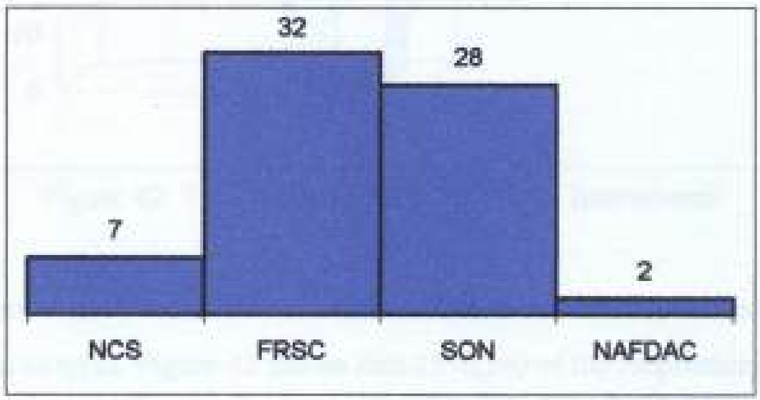


Figure 40: Agency Responsible for Quality Control (Standard) of Tyre

Note:
NCS = Nigeria Customs Service
FRSC = Federal Road Safety Corps
SON = Standards Organisation of Nigerian
NAFDAC = National Agency for Food, Drug and Administration and Control

24. How and where a tyre is removed, repair and fix place an important aspect of tyre maintenance. The analysis of Tables 3.26 and 3.27 revealed that 79%(58) and 21%(15) of the respondents repaired tyre(s) through roadside/local vulcanizers and mechanized vulcanizers

respectively (Figure 41). In doing this, 73%(55) are carried out using local tyre implements and 27%(20) are done with the aid of industrial tyre machines (Figure 42)

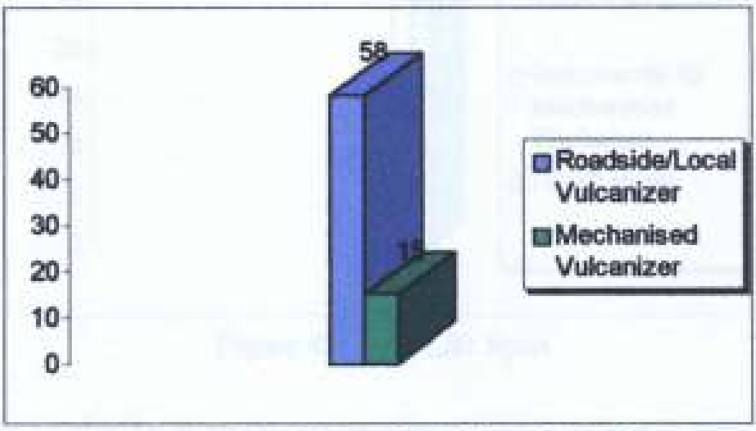


Figure 41: Tyre Removing/Fixing Workshop

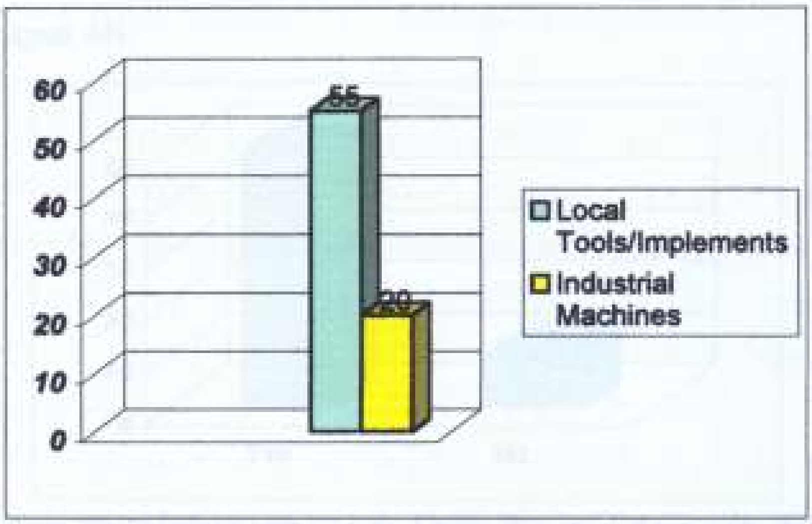


Figure 42: Tyre Removing/Fixing Tools/ Instruments

25. The respondents were asked to determine which of these tools/ instruments can prolong the life span of tyres. Figure 43 shows that 15%(10) of the respondents believe using local implements do prolong the life span of tyres, 46%(30) thinks otherwise while 39%(25) of the respondents have no idea. Evaluating this response with Figures 41 and 42 above, it could be seen that despite the fact that the use of Industrial machines prolong tyres life span, majority of the respondents still carry out tyre repairs through roadside/local vulcanizers. This could be attributed to financial constraint.

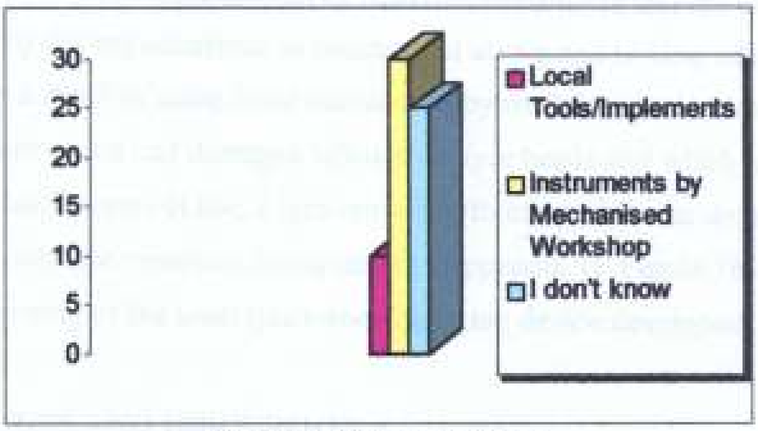


Figure 43: Tyre Life Span

27. The analysis of Table 3.29 identify that there are some deficiencies in the use of local tyre removing/fixing device as 83%(50) of the respondents believe that these devices could be improved upon(Figure 44).

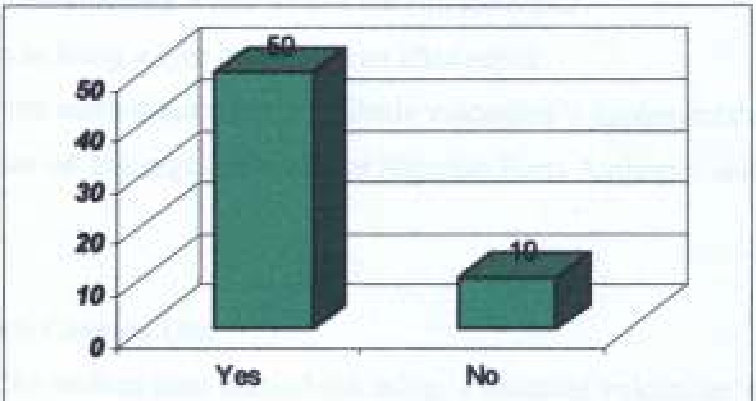


Figure 44: Improvement on Local Tyre Removing/Fixing Devices

28. In correlation with Table 3.29 above, some of the respondents suggested the following as steps that could be taken in improving local tyre removing/fixing device.

i) Nigerian Higher Institutions should be commission to research into ways of improving local tyre removing/fixing device.

ii) Imported tyre removing/fixing machines should be copied and localized.

The experiences of vehicle owners in the hands of various vulcanizers in Nigeria aptly show the ignorance, use of sub-standard or non-functional equipment, low level of education, if any, and the unwillingness of artisans to change despite the negative impact of their services to safety on the roads. What an average Nigerian vulcanizer concern himself with is the pay that comes from the shady works on tyres without proper understanding of the rudiments of their jobs in addition to what appeared as sub-standard equipment which they used (Punch Newspaper, 2004).

To correct the problems encountered by roadside vulcanizers and the use of modern tyre removing equipment by big organizations as enumerated above and in view of the lapse and problems observed as a result of using local instruments by roadside/local vulcanizers which among others things are wears and damages inflicted on tyre beads and which has an effect on the reliability of automobile tyres in use, a tyre removing/fixing device was develop; an improvement on the local tyre removing/fixing device (Appendix 1). Figure 16 shows the schematic working drawing of the local tyre removing/fixing device developed.

4.2 TESTS, RESULTS AND DISCUSSION

4.2.1 Test of the Machine

To evaluate the performance of the constructed manual tyre removing and fixing device, tests were carried out to determine the followings:

1. The time taken in breaking the bead of a tyre from a car rim.
2. The time taken in removing a tyre from a car rim for repair.
3. The time taken in fixing a tyre into a car rim after repair.

Similar tests were carried out using a roadside vulcanizer's implements and imported tyre removing/fixing machine of big organizations like Nigerian Ports Authority and Moragoff Arrow Int. Ltd.

4.2.2 Results of Tests Carried Out

The results of the various tests carried out using, a roadside vulcanizer's tyre removing/fixing implements, an imported tyre removing/fixing machine and that of a constructed tyre removing and fixing device is shown in Table 3 below.

Table 3: Time Spent in Tyre Removing and Fixing Process.

OPERATIVES	Time (Min) of Performing the Operation of														
	Breaking of Tyre Bead					Removing Tyre Bead from Car Rim					Fixing Tyre Bead into Car Rim				
	1	2	3	4	AVE-RAGE	1	2	3	4	AVE-RAGE	1	2	3	4	AVE-RAGE
OPERATOR 1	2	3	5	3	3	3	2	3	3	3	3	3	4	3	3
OPERATOR 2	2	3	3	3	3	3	3	2	3	3	3	3	2	3	3
OPERATOR 3	3	3	3	3	3	3	2	2	4	3	2	2	3	3	3
OPERATOR 4	2	3	3	3	3	4	4	3	3	4	3	4	3	3	3
OPERATOR 5	3	3	3	3	3	2	2	2	2	2	2	2	2	2	2
OPERATOR 6	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
OPERATOR 7	3	3	3	3	3	2	2	3	2	2	2	3	3	3	3

Operators 1, 2, 3 and 4 are roadside vulcanizers using local tools/implements; operator 5 stand for an operator working in Nigerian Ports Authority, Lagos using an imported tyre removing/fixing machine, operator 6 is tyre operator working at in Moragoff Arrow Int. Ltd, a tyre vulcanizing workshop using a sophisticated tyre removing/fixing machine, while operator 7 is an operator using the constructed manual tyre removing and fixing device.

NOTE:

The timing of the tyre removing or fixing operations excludes the following:

1. Time taken in removing the tyre assembly from the car(vehicle)
2. Time taken in inflating air into the tyre assembly to detest where the fault is.
3. Time taken in deflating the tyre assembly prior to breaking of the tyre bead.
4. Time taken in repairing the damaged tyre or tube or rim depending where the fault lies.
5. Time taken in inflating air into the repaired tyre assembly.
6. Time taken in fixing the repaired tyre assembly on the car (vehicle).

These time were not used in discussing and comparing the performance of the roadside vulcanizer implements with that of the constructed manual tyre removing and fixing device and that of the tyre used in industry because they are operations not performed on these devices or implements.

4.3 Discussion

From the result of tests carried out and observations made during the process of repairs using the 3 types of tyre removing and fixing devices; a roadside tyre removing/fixing implements, an imported tyre removing/fixing machine and that constructed manual tyre removing and fixing device, the followings were observed:

4.3.1 Road Side Vulcanizers

Using the roadside vulcanizer's tools/ implements the following were observed:

1. An average of two wounds were noticed inflicted on the tyre beads or the car rim during the process of removing the tyre from the car rim. This is as a result of the heavy iron rod used in forcing the tyre bead from the car rim (Figure 45).
2. Similarly, an average of two wounds were equally inflicted on the tyre bead or car rim during the process of fixing the tyre back into the car rim (Figure 46).
3. The possibility of particles e.g. sand, small stones, entrapped inside the tyre assembly while fixing the tyre into the car rim is high. This is due to the bead breaking or tyre fixing

process being done on the ground (Figure 47).

4. The energy dissipated in tyre bead breaking is smaller compare to the energy used in either tyre removing or fixing process.

Figure 45: A Roadside Vulcanizer in Tyre Removing Operation

Figure 46: A Roadside Vulcanizer in Tyre Fixing Operation

Figure 47: A Roadside Vulcanizer in Tyre Bead Breaking Operation

4.3.2 An Imported Tyre Removing/Fixing Machine

Using an imported tyre removing/fixing machine revealed that:

1. There were no wounds inflicted on the tyre bead or rim while removing the tyre from the car rim.
2. There were no wounds on the tyre bead or rim while fixing the tyre back into the car rim.
3. There were no particles or sand entrapped inside the tyre assembly because repair work was carried out on an elevated platform.
4. Less energy is dissipated by the operator since the machine is either hydraulically or pneumatically controlled.

4.3.3 The Manual Tyre Removing and Fixing Device Developed

Using the manual tyre removing and fixing device, the following were noticed:

1. There were no wounds inflicted on the tyre bead or rim while removing the tyre bead from the car rim. This is made possible with the use of the dismount bar and lubrication of the tyre bead with a soapy water which causes the tyre bead to slip in or out of the car rim without the use of a heavy iron rod.
2. Equally noticed was that no wound on the tyre bead or rim while fixing the tyre back into the car rim. The remount bar and lubrication of the tyre bead makes this process easier and trouble-free.
3. The possibility of particles entrapped inside the tyre assembly using the manual tyre removing/fixing device is most remote because the breaking of the tyre bead, the removing or fixing of the tyre into a car rim is either done on the channel base or the mounting disc which are far above the ground where sand or small stones could be picked easily.
4. The cost of production and maintenance of the manual tyre removing and fixing device is much cheaper than that of the imported tyre removing/fixing machine.
5. The manual tyre removing and fixing device can be use anywhere and require no electricity to either power the device or its auxiliary attachments as required on most imported devices.
6. The operational sequence of the manual tyre removing and fixing device is simple and could carried out easily bearing in mind the educational level of our roadside vulcanizers.

4.5 Deduction from the Secondary Data

These documents revealed that:

i. In US and UK tyre statutory laws are well enacted and documented for the use of every tyre user (manufacturers, sellers and motorists)

ii. In US, tyres are not safe and should be replaced when the tread is worn down to $1/16^{th}$ of an inch.

iii. In US, it is compulsory for tyre manufacturers to build a tyre tread wear indicator into the tread pattern

iv. In UK, the grooves of the tread pattern of every tyre fitted to a vehicle shall be of a depth of at least 1.6mm throughout the continuous band comprising the central three-quarters of the tyre.

v. Tyre pressures should be checked every two weeks.

vi. Tyres must be suitable for the purpose for which the vehicle is being used.

vii. The tyre standards in Nigeria were enacted in 1989 (over 15 years ago). A critical look at it reveals that the laws need serious review. It does not conform with present day reality and internationally known tyre standards.

viii. In our tyre standard booklet, some of the standards are mere definitions while some are too technically worded that they have no clear understanding to the ordinary motorists on the road.

4.5 How To Check or Identify Tyre That May Fail While Buying A Second- Hand Tyres.

When finances do not permit a needed new set of tyres, second-hand ones are what you need and of course, when you buy a pre-owned car, you buy pre-owned tyres.

Taken into consideration the condition or state of roads in Nigeria and the maintenance culture of the people, the following could be checked when buying a second-hand automobile tyre in order to determine if the tyre will fail in use.

- Check For Tyre Tread Depth.

Check the tread pattern over the complete circumference of the tyre. Check also that the tread depth meets the requirements using, as necessary, a depth gauge accepted by the Ministry of Transport (MOT). The tread depth of a new automobile tyre is at least 14mm while the least recommended tread depth for a part-worn tyre is 1.6mm. The use of Nigeria 50 kobo coin will be useful in this regard. Procedures for checking are (Figure 48):

i. Take a 50 kobo coin and pinch it between the thumb and fore-finger.

ii. Put the 50 kobo coin into one of the grooves on the tyre tread. Select some points on the tyre where the groove appears the lowest.

iii. If the top of the tyre treads levels with the bottom edge of the coat of arms on the coin, the tyre

tread is still okay and may not fail in use because at this mark the tyre thread is about 5.25mm

iv. If the tyre treads levels at the top of the date written on the 50 kobo coin, the tyre is still manageable and may not fail in use because the tyre tread still stands at about 3.00mm.
v. If the entire date on the 50 kobo coin is visible, the tyre is recommended for replacement if in use or should not be brought because the tyre tread is less than 2.00mm and may fail in use.

Figure 48: Using Nigeria 50 Kobo Coin to Check Tyre Tread Depth

Other tyre tread gauging instruments are shown in figure 49.

- **Check For Tyre Wear.**

By visual inspection, check for tyre wears e.g. one-sided ear, center wear, shoulder wear, e.t.c. If 50% of the tyre tread have wears, the possibility that this tyre will fail in use is high. Thus such tyre should not be brought or should be replaced if already in use.

- **Check For Cuts On The Tyre Bead.**

By visual inspection, check for visible cuts on the bead of the tyre you intend to buy. Where over 4 cuts appear on both sides of the tyre bead, the possibility of its failure is high. A cut on tyre bead prevents the proper sitting of the tyre into the car wheel. The result of such improper sitting is leakage of air, which may lead to under-inflation to which may result into tyre wears.

- **Check For Tears On The Sidewall (Inner And Outside) Of The Tyre.**

Tyre sidewall-tread-sidewall strips may have tears (cracks, cuts or bulges), shock *ruptures* (from kerbing, potholes, e.t.c), rubbing and abnormal deformations, which may have being treated or left un-treated. To detect these tears, press down the tyre to bulge a little by the sidewall. If there were treated or un-treated sidewall on the tyre they would be visible. All treated sidewall is an indication that such tyre in recent past had tears and cuts which if not properly retreated may fail in use. Avoid buying tyres will such marks.

4.6 Tyre Safety Tips

Any tyre, no matter how well constructed, may fail in use as a result of punctures, impact damage, improper inflation, overloading, or other conditions resulting from use or misuse. Tyre failure may create a risk of property damage, serious personal injury or death. Serious personal injury or death may result from a tyre failure. Many tyre failures are preceded by vibration, bumps, bulges or irregular wear. If a vibration occurs while driving your vehicle or you notice a bump, bulge or irregular wear, have your tyres and vehicle evaluated by a qualified service person.

It is not often that a properly maintained tyre will "blow out" while driving. More commonly if air is lost, it will be gradual. In a case of a blow-out or sudden tyre failure the following information would be helpful:

When the failure occurs, the vehicle may pull toward the side of the failed tyre. Slowly remove your foot from the accelerator, hold the steering wheel firmly, and steer to maintain your lane position. Once the vehicle has slowed and is fully under control, apply the brakes gently. Gradually pull over to the shoulder and come to a stop.

4.6.1 Tyre Inflation

Always keep the vehicle manufacturer's recommended air pressure in all tyres, including the spare. This is an important requirement for tyre safety and mileage. Vehicle's tyre placard or owner's manual will tell the recommended cold air pressure. On some vehicles, the recommended front and rear tyre pressures will be different. Driving on tyres with too little air pressure is dangerous. Tyres will get overheated. This can cause a sudden tyre failure that could lead to serious personal injury or death.

Under-inflation may also:

1. damage the tyre leading to tyre failure.
2. adversely affect vehicle handling.
3. reduce tyre life.
4. increase fuel consumption.

Driving on tyres with too much air can be dangerous. The tyres are more likely to be cut, punctured, or broken by sudden impact. Serious personal injury or death could result.

Tips For Safe Tyre Inflation

- Check tyre air pressure, including spare tyre, at least once a week and before long trips. Be sure to use an accurate pressure gauge and where possible owned a personal pressure gauge as shown in Figure 50.
- Check air pressure when the tyres are cold. The tyres are cold when your vehicle has been driven less than a mile at moderate speed or after being stopped for three or more hours.
- If air must be added when tyres are hot, four pounds per square inch (psi)(28 kPa) should be added above the recommended cold air pressure. *Recheck the inflation pressure when the* tyre is cold.
- Never release air from a hot tyre in order to reach the recommended cold tyre pressure. Normal driving causes tyres to run hotter and air pressure to increase. If air is released when tyres are hot, the tyres may be dangerously under-inflate.
- If tyres lose more than two pounds per square inch (2 psi)(14 kPa) per month, the tyre, the valve, or wheel may be damaged.
- Check spare tyre often. Consult vehicle owner's manual for the correct inflation and use of a "temporary use" spare tyre.
- Use valve caps to keep valve cores cleats, clear of debris and to help guard against air leakage.
- Driving vehicle in an overloaded condition is dangerous. Overloading causes excessive heat to build up in tyres. This can lead to sudden tyre failure and serious personal injury or death while the tyre is overloaded or at some later date.

4.6.2 Tyre Damage

Driving on damaged tyres is dangerous. A damaged tyre can suddenly fail causing serious personal injury or death. Have tyres regularly inspected by qualified tyre repairers for damage.

Tips For Spotting Damaged Tyres

- After striking anything unusual in the roadway, ask a qualified tyre repairer to demount the tyre and inspect it for damage. A tyre may not have visible signs of damage on the tyre surface. Yet, the tyre may suddenly fail without warning, a day, a week, or even months later.
- Inspect tyres for cuts, cracks, split or bruises in the tread and sidewall areas. Bumps or bulges may indicate a separation within the tyre body. Have tyre inspected by a qualified tyre repairer. It may be necessary to have it removed from the wheel for a complete inspection.
- Inspect tyres for adequate tread depth. When the tyre is worn to the built-in indicators at

2/32nd inch (1.6 millimeters) or less tread groove depth, or the tyre cord or fabric is exposed, the tyre is dangerously worn and must be replaced immediately.

- Inspect tyres for uneven wear. Wear on one side of the tread or flat spots in the tread may indicate a problem with the tyre or vehicle.
- Inspect rims also. If you have a bent or cracked rim, it must be replaced.

4.6.3 Tyre Repairs

- Driving on an improperly repaired tyre is dangerous. An improper repair can cause further damage to the tyre. It may suddenly fail, causing serious personal injury or death.
- Never repair a tyre with less than 2/32nd inch (1.6 millimeters) tread remaining. At this tread depth, the tyre is worn out and must be replaced.
- Never repair a tyre with a puncture larger than 1/4 inch (6.4 millimeters) in diameter. Such tyres cannot be properly repaired and must be replaced.
- Never repair a tyre with a puncture or other damage outside the tread area. Such tyres cannot be properly repaired and must be replaced.
- Any tyre repair done without removing the tyre from the rim is improper.
- Tubes, like tyres, should be repaired only by a qualified tyre service person.
- Never use a tube as a substitute for a proper repair.
- A tyre's speed rating is void if the tyre is repaired, retreaded, damaged or abused, or otherwise altered from its original condition. Thereafter, it should be treated as a non-speed-rated tyre.

Removing and Replacing Tyres on Rims (Tyre Mounting)

- Always stand well clear of any tyre mounting operation. This is especially important when the service operator inflates the tyre. If the tyre has been improperly mounted, it may burst with explosive force causing serious personal injury or death.
- A new valve must be installed on the rim each time a worn out passenger or light truck tyre is replaced.
- Removing and replacing tyres on rims can be dangerous. Attempting to mount tyres with improper tools or procedures may result in a tyre explosion causing serious personal injury or death.

Serious personal injury or death can result from:

- Failure to select the proper tyre and rim. The tyre must match the width and diameter requirements of the rim. For example, when mounting 16-inch diameter tyres, use only 16-inch diameter rims. When mounting truck type radial tires, use only wheels approved for radial tyres.
- Failure to inspect both the tyre and rim. The rim must be free of cracks, dents, chips, and rust. The tyre must be free of bead damage, cuts, and punctures.
- Exceeding the maximum bead seating pressure. The tyre service person must never inflate a tyre beyond 2 76kPa or 40 pounds per square inch (psi) to seat the beads. Be absolutely certain beads are fully seated before adjusting inflation pressure to the level recommended for vehicle operation.

Never put flammable substances in tyre /rim assemblies at any time. Never put any flammable substance into a tyre / rim assembly and attempt to ignite to seat the beads.

(a) Michelin Manual Tyre Tread Gauge

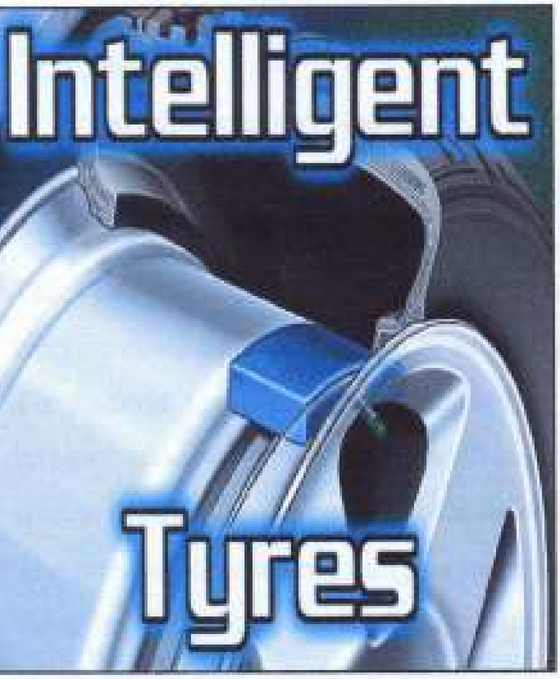
(b) Mustang Tyre Tread Depth Gauge

Band 1	Red	0.0-1.6 mm	Illegal
Band 2	Yellow	1.6-2.0 mm	Caution
Band 3	Green	2.0-8.0 mm	Safe

Bezel Dia	Reading	Range	Graduation
58 mm	0.1 mm	8 mm	0- 8.0

(d) Baker's Tyre Gauge

Figure 49: Various Types of Tyre Tread Depth Gauge



) Intelligent Tyre Pressure Gauge

(b) The Working Principle of Intelligent Tyre Pressure Gauge

c) Mustang Tyre Pressure Gauge

igure 50: Various Types of Tyre Pressure Gauge

CHAPTER FIVE
CONCLUSIONS AND RECOMMENDATIONS

1. Conclusions

From responses received above, it could be concluded that:

Most tyre users and sellers in Nigeria are ignorant of rules and regulation and standards guiding automobile tyres.

There is confusion among the motorists on which agency is responsible for quality control of tyre(standards) and effecting tyre rules and regulations.

The Federal Agencies responsible for tyre standardisation, safety and maintenance based the interpretations of tyre laws on "self" known laws. They cannot produce documentary or statutory books at the point of making seizure or arrest of a presumed tyre offenders.

The present Nigeria laws on tyres lacks some basic technical information which are vital to the over-all quality control(standard) and tyre safety rules and regulations.

Most vehicle owners rely on visual inspection of tyre to determine tyre tread depth, tyre pressure, etc and most tyre pressure gauges use by roadside/local vulcanizers is obsolete and unreliable.

The development of a manual tyre removing and fixing device represents a marked improvement on the local maintenance of road wheel of motor vehicles. This machine is an improvement on the type used by local/roadside vulcanizers. It is a development that laid emphasis on solving some of the problems facing by the roadside vulcanizers, and the various factors causing damages on tyres. Problems such as sand entrapment in repaired tyre assembly, wounds on tyre bead and rims had been eliminated through this project.

Only car rim sizes below 38.10 cm (15'') can be handled by this machine.

The cost of producing this device is less than ₦16, 000:00. The method of operating the machine is easy and does not need a higher academic degree or knowledge to operate.

The machine ensures a safe working condition and effective and efficient operation with little maintenance.

2 Recommendations

Based from observation from responses from questionnaires and witnessing the spection/ examination of imported tyres by men of the Nigeria Customs Service and Standards rganisation of Nigeria at Nigerian Ports Authority, Lagos, the following are recommended:

- The Federal Government through an act of the National Assembly enact and circulate for public consumption laws and regulations on tyre standard, rules and safety.
- The Federal Government should review the present standards of tyres with a view of making it Internationally at par with those in developed countries like UK and US.
- The tyre standards should be clear, unambiguous and simple for the citizens to read and understand.
- The relevant agencies for tyre standard, rules and regulations e.g. Standards Organisation of Nigeria, Federal Road safety Corps, Nigeria Customs Service, etc, should be strengthening for them to perform their statutory duties very well.
- Tyre safety rules and maintenance should be included into our school curriculum especially at the secondary school level.

5.3 Area Needing Further Research

Tyre safety and maintenance would be more comprehensively appreciated and valued if further research work could be carried out on tyre retreading and an improvement on the quality of tools/implements use by roadside vulcanizers in tyre repairs, especially on this device to accommodate tyres of car rim sizes above 3,810cm. These are cars such as jeeps and buses of gross weight above 1,600kg.

REFERENCES

Barbra, Z. M. A. (2004). Definition of Evaluation. Prism Evaluation Consulting Services. (http//: www.evalautionpractice.com).

Brainy Dictionary, 2004. Definition of Evaluation and Reliability. (http//: www.drainydictionary.com)

Bryan, I. (1999). Used Tyre Working Group. The Ban on the Disposal of Tyres to Landfill. 16th July, 1999. (http://www.tyredisposal.co.uk/landfill.asp)

Brown, P. (2002). The new Skid Row-homes built from Tyres. SocietyGuardian.co.uk© Guardian Newspapers, Saturday July 20, 2002.(http//: www.society.guardian.co.uk).

Corghi Tyres Changers. (wewautomation.com/corghi/tyrechagers/tyrechanger2.htm)

EUROPA. (2002). Definition of Evaluation. European Union Portal site. (http//: www.europa.eu.int).

French, M. (1990). A History of US Tyre Industry. The Grolier Multimedia Encyclopaedia. Copyright© TLC Properties.

French, T. (1989). Tyre Technology. The Grolier Multimedia Encyclopaedia. Copyright©TLC Properties.

Hall, A. S., Holowenkwo, A. R., Laughlin, H. G., Hills, P. C. and Bernnet, M. D. (1983). Theory and Problems of Machine Design, SI (Metric) Edition. McGraw-Hill Book Company, Singapore.

Hornby, A. S. (1995).Definition of Reliability. The Oxford Advanced Learner's Dictionary of Current English (Fifth Edition). ISBN: 0550120114

The News Magazine, 2004. Alarm over Tired Tyres. Pg 42, Vol. 23 of November 22, 2004.

Leitch, R. D. (1988). Basic Reliability Engineering Analysis. Elsevier Science & Technology Books (Publisher). ISBN: 0-408-01830-5/0408018305

Martin, E. (2001). US Department of Transport's Highway Traffic Safety Administration. Many U S Passenger Cars Are Driven On "Bald" Tyres, NHTSA Research Shows. 30th November, 2001. (http//: www.dot.gov/affairs/nhtsa6101.htm).

Michelin. (1997). Tires. The essential Tire Guide. Lesson Four. Tire Designations. Copyright© 1997 Michelin Photos: Michelin / DPP1. (http://www.michelin- us.com/us/eng/lesson4.html)

Olanguju, K. (2002). Safe Driving and Vehicle Care. Vanguard Newspaper 28th March, 2002

Oloyo, R. A. (2001). Fundamentals of Research Methodology for Social and Applied Sciences. ROA Educational Press. ISB 978-052-105-4

Punch Newspaper, 2004. Beware; Vulcanizers can put your life in danger. Pg A4-A6, Saturday Punch, August 21, 2004.

Readers Digest Complete Car Manual. (1981). Reader's Digest Association.

UK Department for Transport. (2000). Think! Road Safety. Tyre Depth, 10th January, 2000. (http//: www.thinksafety.gov.uk/tyresafety).

William, H. C. (1975). Automobile Mechanics. McGraw-Hill Book Company, Singapore.

Wilson, D. (2000). Tyre Sales and Information for the UK consumer. Technical Information on Car Tyres. 4th January, 2000. (http//: www.tyre-online.co.uk).

APPENDIX 1: DESIGN ANALYSIS/ COMPONENT DESIGN.

Figure 51 shows the full scale drawing of the bevel gear and pinion which reveals.

i) L, cone distance = $100mm$ ($0.1m$)

ii) b, face width = $30mm$ ($0.03m$)

iii) α_g, pitch angle (gear) = 74^0

iv) $D_g = pitch\ diameter\ of\ gear = 192mm\ (0.192m)$

v) $N_g = Number\ of\ teeth\ (gear) = 32$

vi) $N_p = Number\ of\ teeth\ (pinion) = 7$

vii) $Gear\ and\ pinion\ are\ made\ from\ Steel,\ BHN = 300,\ 20^0\ full\ depth;\ tooth\ error = 0.01$ (*Assum*

viii) $\Pr essure\ angle = 20^0$

ix) $The\ gear\ is\ a\ straight\ tooth\ bevel\ gear$

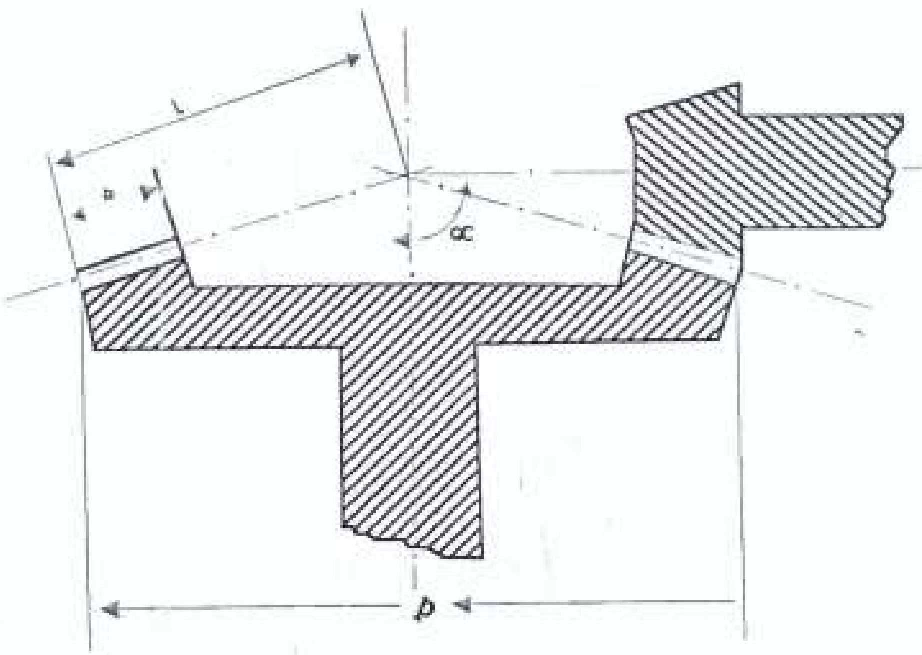


Figure 51: Bevel Gear and Pinion

1.1 Tangential Force, F_t

$$F_t = \frac{M_t}{r_m}$$

Where

$M_t = pinion\ torque$

$r_m = mean\ pitch\ radius$

$r_m = R_r - \frac{1}{2} \times b \times \sin\beta$

$= 21 - \frac{1}{2} \times 30 \times \frac{21}{100}$

$= 17.85mm$

$= 0.018m$

$M_t = F \times r$

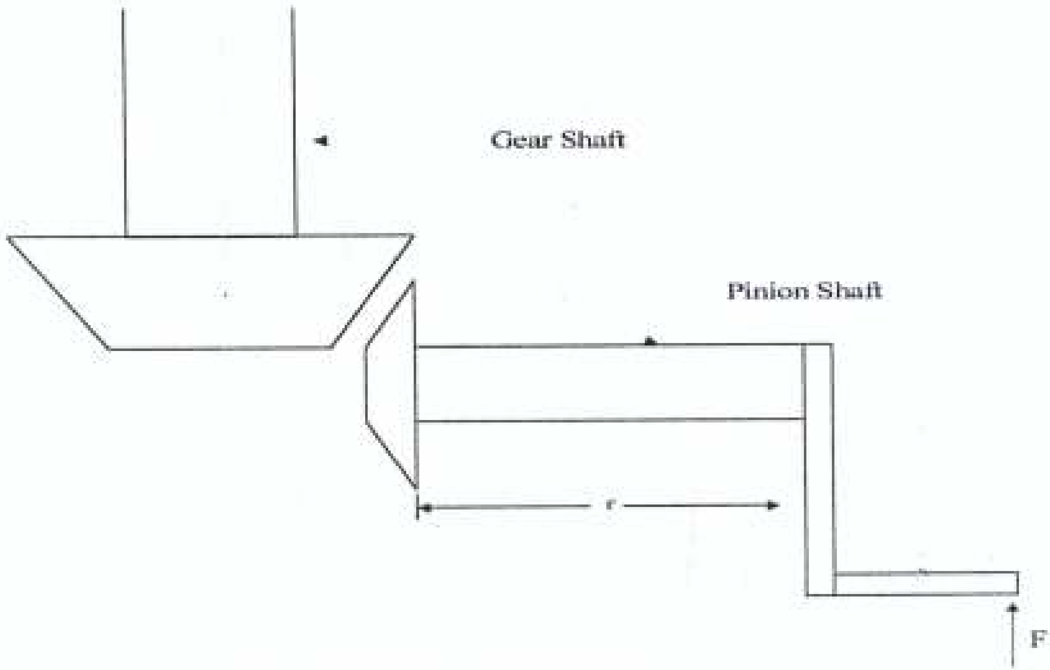


Figure 52: Pinion and Bevel Gear Arrangement

We know that,

The length of the pinion shaft $= 295mm\ (0.295m)$; see appendix

$F = 25kg \times 9.81m/s$; gotten from the average pull of men using a spring weight

Hence

$M_t = 25 \times 9.81m/s \times 0.295Nm$

$= 72.35Nm$

Therefore

$F_t = \frac{M_t}{r_m}$

$F_t = \frac{72.35}{0.018}$

$= 4019.44N$

1.2 Separating Force, F_r

This is a force component along the shaft axis of the pinion.

$F_r = F_t \times \tan\phi$

Where

$F_t = \tan gential\ \ force$

$\phi = pressure\ \ angle$

$F_r = 4019.4 \tan 20°$

$= 1462.95N$

1.3 Pinion Thrust Force, F_p

This is a force component along the shaft axis of the pinion.

$F_p = F_t \tan\phi \sin\beta$

$= 4019.44 \tan 20° \times \dfrac{21}{100}$

$= 307.22N$

1.4 Gear Thrust Force, F_g

This is a force component along the shaft axis of the gear

$F_g = F_t \tan\phi \cos\beta$

$= 4019.44 \tan 20° \times \dfrac{96}{100}$

$= 1404.43N$

1.5 Module, m

The module is the number of millimeters of pitch circle diameters (p.c.d.) per tooth. The pitch circle diameters are the diameters of discs which would transmit the same velocity ratio by fraction as the gear wheels.

$D_p = m_p \times N_p$ -------------------(3.1)

$D_g = m_g \times N_g$ -------------------(3.2)

Where

$\mathrm{D}_p = pitch\ diameter\ of\ \ pinion$

$\mathrm{D}_g = pitch\ diameter\ of\ \ gear$

$m_p = \mathrm{mod}\,ule(pinion)$

$m_g = \text{mod}\,ule(gear)$

$N_p = Number\ of\ teeth\ on\ pinion$

$N_g = Number\ of\ teeth\ on\ gear$

$$m_g = \frac{D_g}{N_g}$$

$$= \frac{192}{32}$$

$$= 6mm$$

1.6 Angular Velocity Ratio, AVR

This is the ration of the angular velocity of the pinion to the angular velocity of its mating gear. It is inversely proportional to the number of teeth on the two gears.

$$AVR = \frac{N_g}{N_p} = \frac{D_g}{D_p}$$

$$AVR = \frac{32}{7} = \frac{192}{D_p}$$

$$= 4.57 = \frac{192}{D_p}$$

$$AVR = 4.57$$

Similarly

$$D_p = \frac{192}{4.57}\,mm$$

$$= 42mm$$

And

$$m_p = \frac{D_p}{N_p}$$

$$= \frac{42}{7}$$

$$= 6mm$$

1.7 The formative or virtual number of teeth, N_f

The formative number of teeth for a bevel gear is the number of teeth having the same pitch as the actual gear that could be cut on a gear having a pitch radius equal to the radius of the back cone.

$$N_f = \frac{N}{\cos\alpha}$$

Where

N = actual number of teeth on the gear

α = pitch angle or half the cone angle.

$D_p = 42mm$

$D_g = 192mm$

$L = 100mm$

$$\cos\alpha_{gear} = \frac{R_g}{L}$$

$$AVR = \frac{21}{100}$$

$= 0.21$

$$\cos\alpha_{pinion} = \frac{R_g}{L}$$

$$= \frac{96}{100}$$

$= 0.96$

Hence,

$$N_{f\,gear} = \frac{N_g}{\cos\alpha_{gear}}$$

$$= \frac{32}{0.21}$$

$= 152.3teeth$

$N_{f\,gear} = 152teeth$

Also

$$N_{f\ pinion} = \frac{N_g}{\cos\alpha_{pinion}}$$

$$= \frac{7}{0.96}$$

$$= 7.2 teeth$$

$$N_{f\ pinion} = 7 teeth$$

1.8 Limiting Wear Load, F_w

$$F_w = \frac{0.75 D_p\ b\ k\ Q}{\cos\alpha}$$

Where

K, stress fatigue factor $= 1372 KMN / m^2$ (Table A.1.1)

And D_p, Q, b are the same as defined and calculated above except α is the Pitch angle of the pinion.

$$Q = \frac{2N_{f\ gear}}{N_{f\ pinion} + N_{f\ gear}}$$

$$\cos\alpha_{pinion} = \frac{2\times152}{7+152}$$

$$= 1.91$$

$$F_w = \frac{0.75\times0.042\times0.03\times10^3\times1.91}{0.21}$$

$$= 2579.57 N$$

Table A1.1: Values for S_{es} as used in the wear load equation upon a combination of the gear and pinion materials. Some values for various materials for both S_{es} and K are tabulated

Average Brinell Hardness Number of steel pinion and steel gear		Surface Endurance Limit S_{es} (MN/ m^2)	Stress Fatigue Factor K(KN/ m^2)	
			$(14\ ½)^0$	20^0
150		342	206	282
200		480	405	555
250		618	673	919
300		755	1004	1372
400		1030	1869	2533
Brinell Hardness Number,BHN				
Steel pinion	Gear			
150	Cast Iron	342	303	414
200	Cast Iron	480	600	820
250	Cast Iron	618	1000	1310
150	Phosphor Bronze	342	317	427
200	Phosphor Bronze	445	503	689
Cast Iron Pinion	Cast Iron Gear	549	1050	1420
Cast Iron Pinion	Cast Iron Gear	618	1330	1960

Source: (Hall, et al, 1983)

1.9 Permissible Force, F

$$F_u = S_o b\ y\ \pi\left[\frac{L-b}{L}\right]m$$

Where

$S_0 = allowable\ bending\ stress,\ N/m^2$

$y = form\ factor\ based\ on\ the\ formative\ number\ of\ teeth\ and\ the\ type\ of\ tooth\ profile$

$L = Cone\ distance,\ m$

$B = face\ width\ of\ the\ gear,\ m$

$m = Module\ based\ on\ the\ largest\ tooth\ cross-section$

From Table A1.2, finding y by interpolation gives

$$\frac{V-0.146}{0.150-0.146} = \frac{152-150}{300-180}$$

$$\frac{V-0.146}{0.004} = \frac{2}{120}$$

$$120V - 17.52 = 0.004 \times 2$$

$$V = \frac{0.008 + 17.52}{120}$$

$$= 0.146$$

based on $N_{f\,gear} = 152\,teeth$

$$S = \frac{M_t}{M^2\, b\, \pi\, y\, N_p} \times \frac{L}{L-b}$$

$$= \frac{2 \times 72.35}{0.006^2 \times 0.03 \times \pi \times 0.146 \times 7} \times \frac{0.1}{0.1-0.03}$$

$$S = 187.28\,MN/m^2$$

$$F = S\, b\, y\, \pi \left[\frac{L-b}{L}\right] m$$

$$F = 187.28 \times 10^6 \times 0.03 \times 0.146 \times \pi \times \left[\frac{0.1-0.03}{0.1}\right] \times 0.006$$

$=10.82\,KN$

Table A1.2: Form Factors y – for use in Lewis strength equation.

Number of Teeth	$(14\frac{1}{2})^0$ Full-Depth Involute or composite	20^0 Full- Depth Involute	20^0 Stub Involute
12	0.067	0.078	0.099
13	0.071	0.083	0.103
14	0.075	0.088	0.108
15	0.078	0.092	0.111
16	0.081	0.094	0.115
17	0.084	0.096	0.117
18	0.086	0.098	0.120
19	0.088	0.100	0.123
20	0.090	0.102	0.125
21	0.092	0.104	0.127
23	0.094	0.106	0.130
25	0.097	0.108	0.133
27	0.099	0.111	0.136
30	0.101	0.114	0.139
34	0.104	0.118	0.142
38	0.106	0.122	0.145
43	0.108	0.126	0.147
50	0.110	0.130	0.151
60	0.113	0.134	0.154
75	0.115	0.138	0.158
100	0.117	0.142	0.161
150	0.119	0.146	0.165
300	0.122	0.150	0.170
Rack	0.124	0.154	0.175

Source: (Hall, et al, 1983)

Hall et al, (1983) was of the view that the amount of force that can be transmitted to a gear tooth is a function of the $S_o y$ product as shown by the Lewis equation. For two mating gears, the weaker will have the smaller $S_o y$ value. Furthermore, when two mating gears are made of the same material, the smaller gear (pinion) will be the weaker and control design. Hence the use of the module of the pinion in calculating the permissible force.

1.10 Limiting Endurance Load, F_o

$$F_o = S_o \, b \, y \, \pi \left[\frac{L-b}{L}\right] m$$

Where

S_o = *Endurance Limit of the gear material for released loading*

And b, y, L, as defined before

But

$$S = S_o \times \frac{5.6}{6.6+\sqrt{V}} \quad \text{for generated teeth}$$

Note: A 7 tooth gear driving a 32 tooth gear will turn the 32 tooth (driven gear) by an approximately 1/5 as fast as the 7 tooth input gear since each gear moves one tooth at a time.

Therefore

$$\text{The speed of the output shaft} = \frac{\textit{Input speed} \times \textit{Driven teeth}}{\textit{Driven shaft}}$$

$$= 5rpm \times \frac{7}{32}$$

$$= 1.09\, rev/\min$$

V = pitch line velocity, m/s

$$= \frac{0.042}{2} \times \frac{1.09 \times 2\pi}{60}$$

$$V = 0.002394\, m/s$$

Therefore

$$F_o = S_o \, b \, y \, \pi \times \frac{L-b}{L} m$$

$$= 188.91 \times 106 \times 0.03 \times 0.146 \times \pi \times \frac{0.1-0.03}{0.1} \times 0.006$$

$$= 74.77\, KN$$

1.11 Dynamic Load, F_d

$$F_d = F + \frac{21V\ bC + F}{21V + \sqrt{bC + F}}$$

Where

$V = pitch\ line\ velocity,\ m/s$

$B = face\ width,\ m$

$C = deformation\ factor, KN/m$

$$F = \frac{gear\ torque}{pitch\ radius\ of\ gear}$$

$$= \frac{2M_t}{D}$$

$$= \frac{2 \times 72.35}{0.042}$$

$F = 3445.23N$

From Table A1.3, $C = 11.4 \times 10^3$ (Steel pinion and Steel gear, 20° full depth of 0.01 Tooth Error).

Hence

$$F_d = F + \frac{21V\ bC + F}{21V + \sqrt{bC + F}}$$

$$= 3445.23 + \frac{(21 \times 0.002394) \times (0.03 \times 114 \times 10^3 + 3445.23)}{(21 \times 0.002394) + \sqrt{(0.03 \times 114 \times 10^3 + 3445.23)}}$$

$= 3449.39$ N

Table A1.3: Values for Deformation Factor C in KN/ m – for dynamic load check

Materials		Involute tooth	Tooth Error – mm				
Pinion	Gear	form	0.01	0.02	0.04	0.06	0.08
Cast Iron	Cast Iron	$(14\ ½)^0$	55	110	220	330	440
Steel	Cast Iron	$(14\ ½)^0$	76	152	304	456	608
Steel	Steel	$(14\ ½)^0$	110	220	440	660	880
Cast Iron	Cast Iron	20^0 full depth	57	114	228	342	456
Steel	Cast Iron	20^0 full depth	79	158	316	474	632
Steel	Steel	20^0 full depth	114	228	456	684	912
Cast Iron	Cast Iron	20^0 stub	59	118	236	354	472
Steel	Cast Iron	20^0 stub	81	162	324	486	648
Steel	Steel	20^0 stub	119	238	476	714	952

Source: (Hall, et al, 1983)

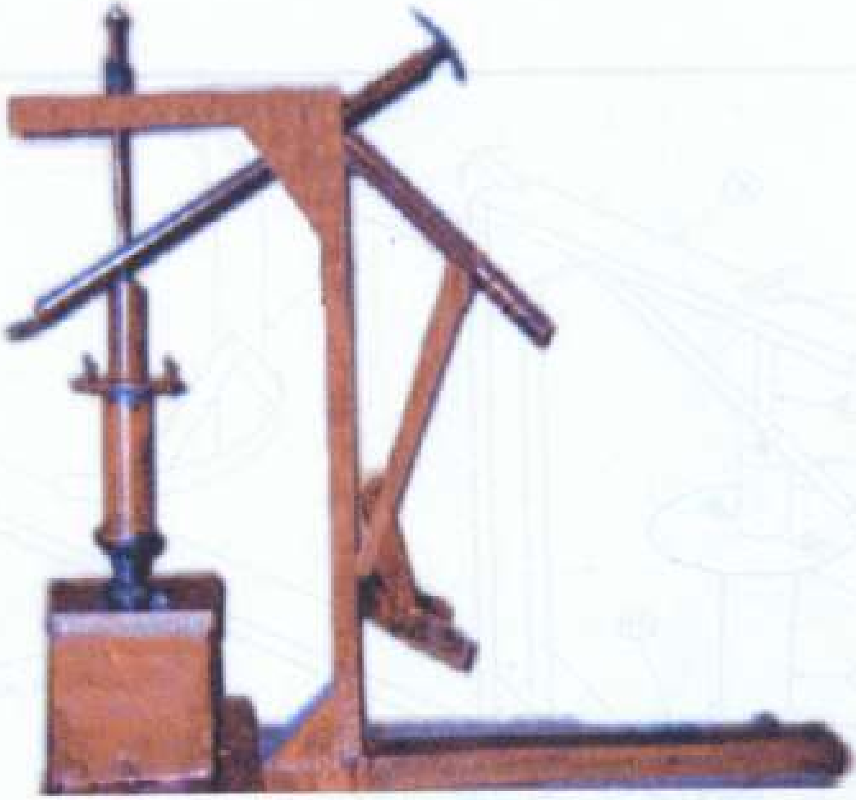
APPENDIX 2: COST ESTIMATE

Below is the estimated cost of fabricating one unit of the tyre removing and fixing device.

Table 2.1: Estimate for the construction of a tyre removing and fixing device

S/N	DESCRIPTION	QUANTITY	AMOUNT	
			₦	K
1	1.5mm Mild Steel Sheet	1	1,200	00
2	Bevel gear and Pinion	1	1,800	00
3	Channel	2	3,000	00
4	Mild Steel Pipe	1	400	00
5	10mm Mild Steel	1	1,200	00
6	Reinforcement bar	2	600	00
7	Angle bar	1	200	00
8	Steel Bushing	2	400	00
9	Driving Shaft	2	600	00
10	Pinion Shaft	1	800	00
11	Tyre Lever	1	600	00
12	Bolt and Nut(M19)	11	165	00
13	Bolt and Nut(M12)	3	30	00
14	Coupling	2	600	00
15	Remounting/dismounting tool	1	950	00
16	Locking Arm	1	200	00
17	Painting		500	00
18	Miscellaneous		2,000	00
TOTAL			15,245	00

APPENDIX 3: PICTURE OF THE TYRE REMOVING AND FIXING DEVICE

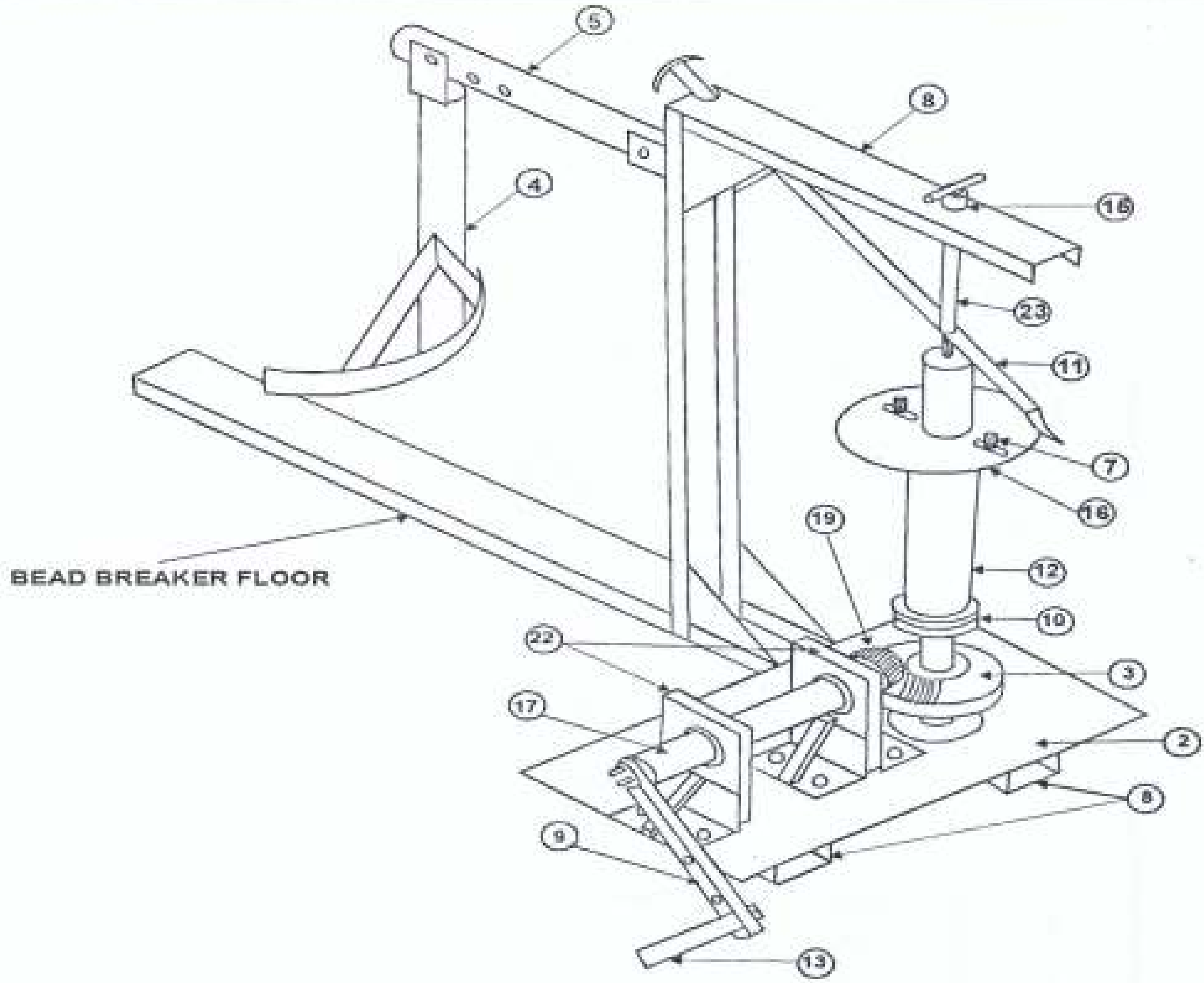


APPENDIX 4: MACHINE DRAWINGS OF THE TYRE REMOVING AND FIXING DEVICE

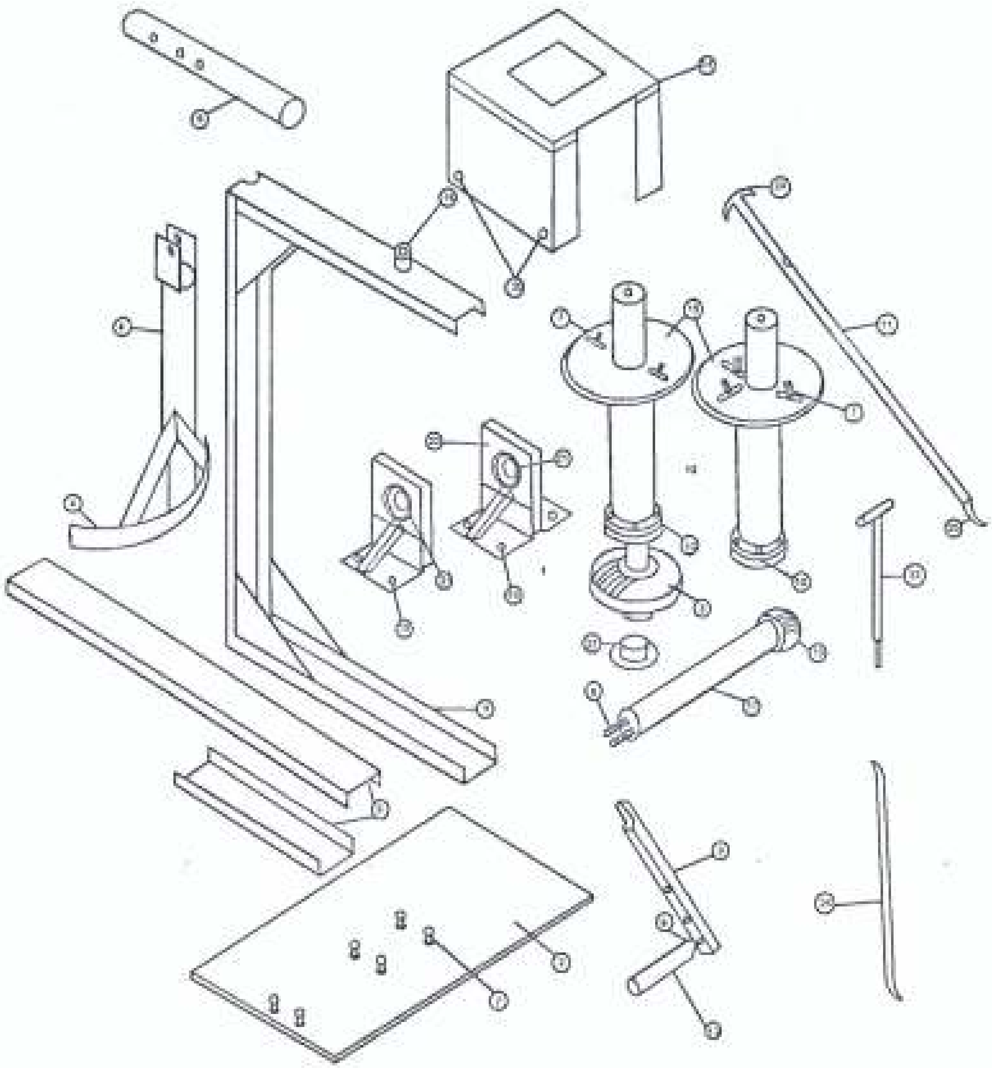
Sheet No 1: Assembly drawing of the device.

Sheet No 2: Part drawing of the device.

Sheet No 3: Machine drawing of the device.

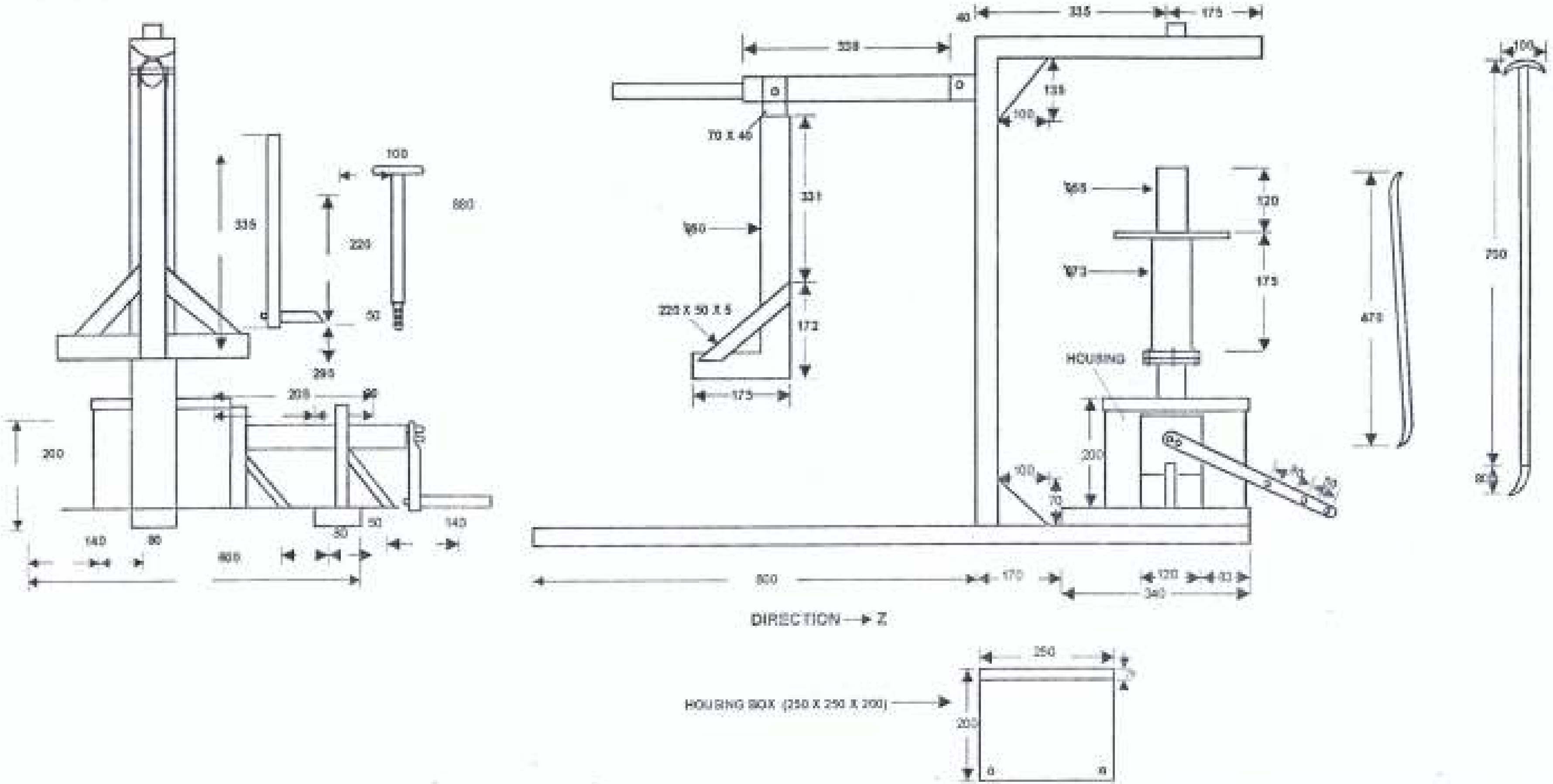


TITLE	A DEVICE FOR REMOVING & FIXING	
TYRES ON A CAR RIM.		
SCHOOL	FEDERAL UNIVERSITY OF	
TECHNOLOGY AKURE, ONDO STATE.		
DESIGN BY	DAFE, TIMOTHY SIVWENOJA	
MATRIC NO	MEE/96/8557	
DRAWN BY	STEPEN NWANKWO	
CHECKED BY	PROF L. O. ADEKOYA	
DATE	SCALE	SHEET NO
FEB 2003	1: 50	01



S/NO	DESCRIPTION	MATERIAL	QTY
27	BEVEL GEAR STAND	STEEL Ø110	1
26	TYRE LEVER	CHROME VANADIUM 650 - 16"	1
25	DISMOUNTING SIDE	STEEL BAR 80 X 20 X 10	1
24	MOUNTING SIDE	MILD STEEL Y12	1
23	LOCKING ARM	MILD STEEL 2/0/ 100 X Y20	1
22	REINFORCEMENT BAR	MILD STEEL 170 / 120 X 20	2
21	BUSHING	STEEL 25 X Ø50	2
20	FLAT SCREW	SELF TAPING SCREW 5mm	6
19	PINION	CHROM STEEL Ø56 X 7 Teeth	1
18	POSITION FOR BOLT	DRILLED 022 BITS	6
17	PINION SHAFT	MILD STEEL 265 X Ø45	1
16	MOUNTING PLATE	MILD STEEL 5mm X Ø200	2
15	LOCK ARM LOCATOR	STAINLESS STEEL 80 X Ø40	1
14	HOUSING BOX	MILD STEEL 1.5mm SHEET	1
13	HANDLE	MILD STEEL 140 X Ø25	1
12	DRIVEN SHAFT	MILD STEEL 175 X Ø73	2
11	RE/DISMOUNT TOOL	MILD STEEL	1
10	COUPLING	MILD STEEL Ø110 X 10	4
9	CRANK ARM	MILD STEEL 350 X 20 X 20	1
8	CHANNEL	MILD STEEL 3040 X 35 X 80	1
7	BOLT A NUT	STEEL M19 X 40	11
6	BOLT A NUT	STEEL M12 X 50	3
5	BEAD BREAKER HANDLE	PIPE Ø50	1
4	BEAD BREAKER	MILD STEEL PIPE FLAT BAR	1
3	BEVEL GEAR	STEEL PITCH Ø192 X 32 Teeth	1
2	BASE PLATE	MILD STEEL 600 X 340 X 10	1
1	ANGLE IRON	MILD STEEL 120 X 70 X 70	3

TITLE	A DEVICE FOR REMOVING & FIXING TYRES ON A CAR RIM.	
SCHOOL	FEDERAL UNIVERSITY OF TECHNOLOGY AKURE, ONDO STATE.	
DESIGN BY	OAFE, TIMOTHY SIVWENOJA	
MATRIC NO	MEE/96/6557	
DRAWN BY	STEPEN NWANKWO	
CHECKED BY	PROF L. O. ADEKOYA	
DATE	SCALE	SHEET NO
FEB 2003	1: 50	02



TITLE	A DEVICE FOR REMOVING & FIXING
TYRES ON A CAR RIM.	
SCHOOL	FEDERAL UNIVERSITY OF
TECHNOLOGY AKURE, ONDO STATE.	
DESIGN BY	OAFE, TIMOTHY SIVWENOJA
MATRIC NO	MEE/98/8587
DRAWN BY	STEPEN NWANKWO
CHECKED BY	PROF L. O. ADEKOYA

DATE	SCALE	SHEET NO
FEB 2003	1: 50	03

APPENDIX 5

A QUESTIONNAIRE ON COMPOSITE EVALUATION OF RELIABILITY OF AUTOMOBILE TYRES

QUESTIONNAIRE INSTRUMENT

This questionnaire is designed to seek your knowledge and understanding of automobile tyres. It is to determine if buyers and users of automobile tyres can easily detect bad or worn-out tyres thus ensuring a good tyre safety and maintenance consciousness.

The research is purely an academic exercise and all information will be treated in strict confidence. Please answer all questions as honestly as possible as your complete anonymity is guaranteed.

A. GENERAL

1. Name of Respondent: ______________________________________(optional)

2. Are you a tyre

   (a) User (b) Seller (c) a & b (d) None of these

3. Which of the following academic qualification do you have?

   (a) WASC / GCE (b) City & Guild (c) ND (d) HND (e) B.Sc (f) M.Sc (g) PhD

   (g) Others (Specify)____________________________________

B. TECHNICAL

1. How many types of tyres do you know?

   (a) Radial (b) Bias-ply (c) Belted-bias (d) I don't know

2. What is the type of wears you noticed on your automobile tyres?

   (a) One-sided wear (b) Centre wear (c) Shoulder wear (d) Spot wear

   (e) Diagonal wear (e) Feather-edged wear (g) I don't know

3. How often do you gauge the pressure of your tyre?

   (a) Weekly (b) Monthly (c) When I notice that the tyre is flat

4. Over/Under inflation of tyre pressure can result in?

   (a) More fuel consumption (b) Less fuel consumption (c) I don't know

5. Tyre pressure is best check when the tyres is

   (a) Cold (b) Hot (c) I don't know

6. How often do you align your vehicle wheel?

(a) Weekly (b) Monthly (c) When I noticed that the vehicle does not keep to a straight path while driving

7. A tyre is regarded as a part-worn tyre if

(a) The tyre tread depth is not below 1.66mm (b) The tyre tread channel is $2/32^{nd}$ of an inch

(c) The tyre tread depth is completely missing (d) I don't know

8. What do you notice when your vehicle tyres are worn-out?

(a) The braking system of the car becomes less effective (b) Steering becomes difficult

(c) Acceleration is hard (d) a & b (e) a & c (f) b & c (g) a, b & c (h) I notice nothing

9. A retreaded tyre is one which

(a) Tyre tread had been replaced (b) tyre tread depth is below 1.6mm (c) I don't know

10. Have you ever used retreaded tyre before?

(a) Yes (b) No

11. If yes, what is the damage notice on the tyres?

(a) Tyre tread chip off easily (b) Frequent tyre puncture (c) Tyre behaves unstable in use

(d) I notice nothing

12. What method do you use in checking tyre tread depth?

(a) Lincoln's penny method (b) Using tyre wear indicator (c) Visual inspection

(d) I don't know

13. What do you notice when you suddenly apply brake to automobile tyres?

(a) The tyre skids (b) The tyre tread wears (c) The tyre surfaces develop flat and bald spots

(d) I notice nothing

14. Have you ever rotated the position of your tyres before?

(a) Yes (b) No

15. If yes, why: ____

____

16. If No, why: ____

____

17. Tyres should be rotated regularly from front to rear and not from side to side.

(a) Yes (b) No

18. Do you buy new tyres while replacing your damaged tyres?

(a) Yes (b) No

19. If yes, why do you prefer new tyres?

____

____

20. If No, why do you buy second-hand or Tokunbo tyres?

____

____

21. The legal minimum requirement of a tyre thread depth is?

    (a) 1.6mm (b) $1/6^{th}$ of an inch (c) I don't know

22. Which of the following organisations is responsible for ensuring for quality control (Standard) of tyre in Nigeria?

    (a) Nigeria Customs Service [NSC] (b) Federal Road Safety Corps [FRSC]

    (c) Standards Organisation of Nigeria [SON] (d) National Agency for Food, Drug and Administration and Control [NAFDAC]

23. Where do you repair your tyres?

    (a) Roadside/Local Vulcanizer (b) Mechanised Workshop

24. How is your tyres removed?

    (a) By use of Local Tools/Instruments (b) By use of Industrial Machines

25. Which one of these tools in tyre repairs can aid long life span for tyres?

    (a) Local Tools/Implements (b) Instruments used in Mechanised Machines (c) I don't know

26. Can the local way of removing/fixing tyres be improve upon?

    (a) Yes (b) No

27. If yes, any suggestion?

____

____

APPENDIX 6

Motor Vehicle Tyres (Safety) Regulations 1994

The above Regulations came into force on 1st June 1995 and make provisions for the supply of new, retreaded and part-worn tyres.

This guidance, however, is limited to the requirements for the supply of retreaded and non-retreaded part-worn tyres.

Main Legal Requirements

In general, the above Regulations provide that it is a criminal offence to supply, agree to supply, expose for supply or possess for supply a part-worn tyre, whether retreaded or not, unless the following requirements are met;

Cuts and Faults

A part-worn tyre must not have:

- any cut larger than 25 millimetres or 10 per cent of the section width of the tyre, whichever is the greater, measured in any direction on the outside of the tyre and deep enough to reach the ply or cord
- any internal or external lump, bulge or tear caused by the separation or partial failure of its structure, or
- any of the ply or cord exposed internally or externally.

To check that a tyre does not have any of the above faults it should be inflated to the highest pressure at which it is designed to operate.

The following requirements must also be met:

- The base of any groove which showed in the original tread pattern of the tyre must be clearly visible.
- The original tread pattern must be of a depth of at least 2 millimetres across the full breadth of tread and round the entire tyre.

Markings

Part-worn non-retreaded tyres must bear:

- The approval mark (E mark), which was put on when it was manufactured.
- Marks showing a speed category symbol and load-capacity index which were put on when it was manufactured.

Part-worn retreaded tyres must bear:

- One of these marks - "BS AU 144b", "BS AU 144c", "BS AU 144d" or "BS

AU 144e" This shows that it was retreaded to British Standards and should have been applied when retreaded.

- If the tyre bears the mark "BS AU 144e" it must also bear a speed category and load-capacity index.

In both cases, immediately adjacent to the marks, the words "PART-WORN" in uppercase letters at least 4 millimetres high must be permanently and legibly applied to the tyre other than by hot branding or otherwise cutting into the tyre.

Repairs

Any repairs to tyres must have been carried out properly to meet the requirements of BS AU 159e: 1990.

What happens if I don't comply with these requirements?

These regulations are made under the Consumer Protection Act 1987 - the maximum penalty on summary conviction is a fine of £5000 and/or up to six months imprisonment. In addition, any offending tyres are liable to seizure and forfeiture. Under the Road Traffic Act 1988 it is an offence if a tyre is fitted which causes the vehicle to be un-roadworthy and a danger to drive, or a danger to other road users. The maximum fine for this is also £5000.

Source: http://www.lots.org.uk/Printerfriendly/pf_bus_motor_vehicle_tyres.htm

U.S. Department of Transportation
Office of Public Affairs
Washington, D.C.
http://www.nhtsa.dot.gov/

News

NHTSA 61-01
Friday, November 30, 2001

Contact: Elly Martin
Telephone: (202) 366-9550

Many U.S. Passenger Cars
Are Driven on "Bald" Tires,
NHTSA Research Shows

U.S. Transportation Secretary Mineta Announces Launch
Of Major Nationwide Campaign to Promote Tire Safety

Responding to new studies showing that a significant number of American motorists are driving on bald tires and that many gas stations that provide air pumps fail to provide accurate tire pressure gauges, U.S. Transportation Secretary Norman Y. Mineta today urged motorists to closely monitor their tires.

"It is extremely important to motorists' safety that they ensure their tires have ample tread and are properly inflated," Secretary Mineta said. "Motorists who drive on tires that are bald or substantially under-inflated risk injuries or fatalities."

To better protect motorists, the U.S. Department of Transportation's National Highway Traffic Safety Administration (NHTSA) is launching a new tire safety campaign based on the theme: "Tire Safety: Everything Rides on It." The purpose of the campaign, to involve radio public service announcements, print ads and brochures, is to stress the importance of proper tire inflation and vehicle load limits. The campaign is also designed to encourage motorists to check their tires monthly, as well as prior to a long trip, to be sure they have adequate tread.

"It is vitally important that motorists monitor tread depth to guard against tire failure and replace unsafe tires. Checking tires is a crucial element in regular vehicle maintenance," said Dr. Jeffrey W. Runge, NHTSA's Administrator.

According to a major survey conducted by NHTSA, fully 9 percent of passenger cars on U.S. roadways are driven with at least one bald tire.

Moreover, another major NHTSA study found that 14 percent of gas stations are either not equipped with air pumps or have malfunctioning pumps. Also, only 49 percent of gas stations that are equipped with air pumps provide tire pressure gauges, which are critical to determining if the correct amount of air has been delivered to tires. However, for a nominal price, motorists can purchase a tire pressure gauge.

To help vehicle owners better monitor the air pressure in their tires, NHTSA in July proposed a new federal motor vehicle safety standard that would require the installation of tire pressure monitoring systems in new passenger cars and light trucks. The new system would warn the driver when a vehicle has a significantly under-inflated tire.

One alternative would require that the driver be warned when the pressure in one or more tires, up to a total of four tires, has fallen to 20 percent or more below the vehicle manufacturer's recommended cold inflation pressure for the vehicle's tires, or a minimum level of pressure to be specified in the new standard, whichever is higher.

The other alternative would require that the driver be warned when tire pressure in one or more tires, up to a total of three tires, has fallen to 25 percent or more below the vehicle manufacturer's recommended cold inflation pressure for the vehicle's tires, or a minimum level of pressure to be specified in the new standard, whichever is higher. Only one version will be in the final rule.

Tire tread provides the gripping action and traction that prevent a vehicle from slipping and sliding, especially when the road is wet or icy. In general, tires are not safe and should be replaced when the tread is worn down to 1/16th of an inch. Tires have built-in tread wear indicators that let a motorist know when they should be replaced. These indicators are raised sections spaced intermittently in the bottom of the tread grooves. When they appear "even" with the outside of the tread, it's time for tire replacement.

Another method of checking tire tread involves use of a Lincoln penny. The motorist should place the penny upside down within the tread. If the top of Lincoln's head is visible, the tire needs to be replaced.

NHTSA's new tire safety campaign will involve three new public service announcements to run on 2,000 radio stations throughout the country; print ads in newspapers and magazines; and more than 500,000 flyers to be given free-of-charge to consumers through tire retail outlets and other channels. Some of the materials will be in Spanish as well as English. Consumers can obtain tire safety information from NHTSA by calling the agency's Hotline: 888-327-4236. NHTSA's new flyer and brochure, both titled "Tire Safety: Everything Rides on It," can be viewed on the agency's web site, www.nhtsa.dot.gov.

Printed materials used as part of the campaign will be distributed by NHTSA as well as Championship Auto Racing Teams, Inc. (CART), the Rubber Manufacturers Association (RMA), and the Tire Association of North America (TANA).

NHTSA's analysis of tire wear was based on information gathered on 6,240 passenger cars during a 14-day period earlier this year. Information for the survey was collected with the cooperation of motorists who visited gas stations for refueling at 300 sites in urban, suburban and rural settings located throughout the country.

To conduct its survey on air pumps at gas stations, NHTSA collected information at the same 300 stations where data were gathered on tire wear. Just 139 of those 300 stations were found to have working air pumps, along with tire pressure gauges. These stations were later revisited to evaluate the accuracy of their gauges.

Key findings of the NHTSA study on tire tread include these estimates:

- Nine percent of passenger cars are being driven on at least one "bald" tire. (For purposes of this survey, a tire was considered bald if it had 1/16th of an inch or less of tread depth.)
- Bald tires are between 1.5 and 1.8 times more likely to be under inflated than are tires with deeper tread, depending on tire location. Key findings of the NHTSA study on gas station air pumps include these estimates:
- Well over 90 percent of U.S. gas stations are equipped with air pumps. However, nearly 10 percent of these pumps are out-of-order.
- Fewer than half of the pump-equipped gas stations also provide a tire pressure gauge for customer use.
- Nearly 20 percent of the stations providing customers with tire pressure gauges on their air pumps use gauges that over-report the pressure present in a tire by at least 4 psi (pounds per square inch) or more. (This means that motorists who use such gauges in the

belief that they are inflating their tires to the recommended pressure would, in fact, be under-inflating them by 4 psi or more.)

- At the pressure levels that are typical for most passenger cars or SUVs, nearly 10 percent of gas station air pump gauges over-report by 6 psi or more.

A NHTSA research survey of U.S. passenger vehicles that was released in August found that 27 percent of passenger cars on U.S. roadways are driven with one or more substantially under-inflated tires. In addition, the survey found that 33 percent of light trucks (including sport utility vehicles, vans and pickup trucks) are driven with one or more substantially under-inflated tires.

A radial tire can lose much of its air pressure and still appear to be fully inflated. Operating a vehicle with substantially under-inflated tires can result in a tire failure, such as instances of tire separation and blowouts, with the potential for a loss of control of the vehicle. Under-inflated tires also shorten tire life and increase fuel consumption.

Tires should be inflated in accord with the vehicle manufacturer's recommendations. These can be found in the owner's manual or on a placard, which is often located in the glove compartment or on the driver's doorjamb. Motorists should not rely on visual tire inspections to determine whether a tire is properly inflated but should use a tire pressure gauge to do so.

Like tires that are under-inflated, bald tires also pose risks to motorists. A tire with insufficient tread can cause a driver to lose traction, especially under wet conditions. In addition, bald tires are more prone to damage caused by road debris.

NHTSA's National Center for Statistics and Analysis conducted the two new studies. Statistics from the studies are contained in research notes on the agency's Website at: www.nhtsa.dot.gov/people/ncsa.

Research Note

Tire Pressure Special Study Tread Depth Analysis

Air Pumps at U.S. Gas Stations: Major Findings Regarding Availability, Reliability and Fees

Return to Press Release Page

Source: http://www.nhtsa.dot/gov

TYRE CONSTRUCTION

All tyres fitted to modern vehicles are tubeless radials. A radial tyre is inherently more flexible than the original cross ply tyre of 30 or more years ago. It gives better cornering grip because the sidewalls can bend whilst still allowing the flatter tread area to remain in contact with the road.

Tubeless construction gives safer deflation characteristics in the event of a puncture, though a few "tube type" tyres are still available for special purposes. It is never recommended to fit tubes to a tubeless tyre: though sometimes due to severe corrosion of the wheel a tube must be fitted to get it to hold air. (The correct procedure, though, is to clean the wheel, and repaint if necessary, to ensure an airtight seal between tyre and wheel).

Tyres for commercial vehicles have stronger sidewalls to carry a greater weight. As a rule, tyre pressures should be checked once a week. Correct maintenance of tyre pressures and wheel alignment is essential to maximise tyre life (as well as safe and comfortable handling of the car).

TYRE SIZES.

Tyre sizes consist of 3 numbers: the width of the tyre, the profile (aspect ratio) and the wheel size: so a tyre size 155.70.13 is 155 mm wide, has a sidewall which is 70% of the width and fits a 13 inch wheel. The tyre size is decided by the vehicle manufacturer. More powerful cars require wider tyres to give more grip (to handle the power output and for better cornering ability). Larger cars also need bigger wheels and tyres to handle the weight of the car.

Tyre profiles range from 85% down to 35%. The lower the profile of the tyre the better the road holding when cornering. This is because the narrower sidewall of the tyre has less room to flex. Low profile tyres tend to give a bumpier ride because the tyre has much smaller sidewalls to cushion minor surface irregularities.

Do not fit a lower profile tyre than originally specified unless you also increase the wheel size to compensate for it; so that the rolling radius of the tyre remains the same! Failure to observe this precaution means the vehicle speedometer will be incorrect; the vehicle will use more fuel; the ride will be uncomfortable and the vehicle may catch the ground over "speed bumps". Tyres, which are too small, may also overheat and your insurance could be invalid.

After the 3 numbers of the tyre size there is usually a number and letter combination, which indicate the maximum load per tyre at a certain maximum speed. The load and speed are determined by manufacturer's design and testing based on the tyre size and tread pattern. A coarse pattern will heat up more quickly therefore a lower speed rating will usually apply at the stated load when compared to a normal pattern.

TYRE SPEED SYMBOLS

For MOT requirements in this country, it is not necessary to fit a tyre with a speed rating to match the original vehicle fitment or the maximum speed of the vehicle. Tyres must be suitable for the purpose for which the vehicle will be used.

Insurance companies might say that a vehicle should be fitted with the tyres having the speed rating recommended by the car manufacturer: but even if you fit Z-rated tyres for speeds over 150 mph they will not insure you if you drive in excess of 70 mph in this country!

The vehicle manufacturer has to recommend a tyre with a rating to match the maximum speed of the car because when it leaves the factory he does not know exactly where the car is going or for what purpose it might be used. You might want to use the car in a country where higher speed limits apply than the UK or take it to a race track at the weekend.

The major tyre manufacturers such as, publish charts showing speed ratings.

The speed rating means the tyre can be run at its maximum speed AND at it's maximum load for an extended period without overheating.

TREAD PATTERNS

The tread pattern is required to disperse water from the road so that the tyre can still grip in wet conditions - otherwise the tyre might aquaplane both when driving and braking. Water dispersal is aided by tiny slots in the tread called sipes. The tread patterns are moulded onto the tyre and generally speaking each manufacturer uses a unique pattern. Most tyre makers market a range of patterns each with different characteristics.

- Summer Conditions
- Winter Conditions
- Wet Conditions
- All Weather Conditions
- High Speed Use

- Off Road Use
- Long Life
- Minimum Road Noise
- Directional Patterns
- Asymmetric Patterns

Some of the tread characteristics are required to suit the particular vehicle application but most can be chosen by the driver to suit his/her own requirements.

If a directional pattern tread is fitted it will give better wet weather performance when fitted the correct way, but is not illegal or dangerous when fitted the wrong way round; nor is it necessary for all the tyres on the vehicle to be directional.

Asymmetric tyres are marked to show which side of the tyre should be fitted to the inner and outer sides of the vehicle. They are designed for maximum cornering grip and should always be fitted the correct way round.

Tyres for high speed use may have a tread compound which is softer than normal thus giving maximum grip but a shorter service life.

The major tyre manufacturers have on-line catalogues: eg.

Uniform Tyre Quality Grading

Tyres have many markings on them to indicate different features. Different markings are required for the European market, for N. America, and for other markets. Some tyres are labelled for all sales areas, some are only labelled for an individual market. The Uniform Tyre Quality Grading System (UTQGS) is an *American* tyre information system, sometimes found on tyres sold in the UK.

- Tread wear
- Traction
- Temperature

Each tyre manufacturer performs its own tests in these areas, following U.S. Government prescribed test procedures. Each manufacturer then assigns grades that are branded on the tyre.

Tread wear

Tread wear grades typically range from 60 to over 500, in twenty point increments. It is important to remember that the actual life of any tyre is determined by the road surface quality, driving habits, inflation, wheel alignment and the rotation it experiencees.

To receive a tread wear grade, a tyre is tested under controlled conditions on a government prescribed test course, which does not necessarily simulate the actual application for which a given tyre is designed to perform. As a result of these test parameters, there is no accurate way to assign miles of wear to tread wear grade points.

Tread wear ratings are determined on a 400 mile government test course covering specified sections of public roads near *San Angelo, Texas*. A group of not more than four test vehicles travels the course in a convoy so that all tyres experience the same conditions. Tread groove depths of the tyres being tested are measured after each 800 miles. The same procedure is followed for a set of control or course monitoring tyres.

Upon completion of the 7,200 mile test, the rating results of both tests are compared, and the tyres being tested are assigned a tread wear rating by the tyre manufacturer. A tyre with a tread wear grade of 400 might be expected to last twice as long as a tyre that has a grade of 200 if given the same usage and driving style.

Traction

Traction grades indicate the measurement of a tyre's ability to stop a car in straight-ahead motion on a wet test surface pavement. It does not measure straight-ahead acceleration. It's important to remember that traction rating tests are performed only for straight ahead sliding on concrete and asphalt surfaces that have a specified degree of wetting which simulates most road surfaces in a rainstorm. The ratings that result from these tests may not apply to cornering traction or peak values of straight-ahead braking force like those experienced in non-skid braking tests. Traction grades range from A to C, with A being the highest attainable grade.

Traction ratings are established on government maintained skid pads. Twenty measurements are taken with an industry standard control tyre on an asphalt surface and averaged. The same number of measurements is made on a concrete surface. Corresponding measurements are then made on the tyres being tested. Once the results of the tests are compared, traction ratings based on government prescribed coefficient levels are assigned to the tyres that were tested.

Temperature

Temperature grades also range from A to C, with A being the highest. Temperature grades represent a properly maintained tyre's ability to dissipate heat under test conditions. Ratings are determined by running tyres on an indoor road wheel test under specified conditions. Successive 30-minute runs are made in 5 mph increments starting at 75 mph and continuing until the tyre fails. A tyre is graded C if it meets the minimum performance required by DOT. Grades of B and A represent higher levels of performance than the minimum required by DOT (US Department of Transport).

To Top of Page || Back to First Page || Site Index & Enquiries

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Source: http://www.tyresave.co.uk/tyreinfo.html

NIGERIAN INDUSTRIAL STANDARD NIS 252:1989

UDC:621.54:629.113.012.5

STANDARD ON
NEW PNEUMATIC PASSENGER CAR TYRES

STANDARDS ORGANISATION OF NIGERIA,
FEDERAL MINISTRY OF INDUSTRIES,
LAGOS.

1

FOREWORD

This standard was originally prepared by the sub-committee on Rubber and Rubber products out finalised by the Technical Committee on Tyres. The standard is intended for quality control purposes by manufacturers and others who deal with or use pneumatic passenger car tyres.

In the preparation of this Standard, references were made to standards obtainable in other countries; and attention was paid to the manufacturing practices and the use of tyres in Nigeria.

MEMBERS OF THE TECHNICAL COMMITTEE

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16. Mr. B. O. Omole (Technical Secretary)	—	"

1. SCOPE:-

This Standard Specified basic design requirements, tests required for type approval, and marking requirements for new pneumatic passenger car tyres of particular size designation, and basic quality requirements for performance.

2. DEFINITIONS:-

For the purpose of this Standard, the following definition shall apply.

2.1. PNEUMATIC TYRES:-

An annular torroidal-shaped inflatable envelope made of elastic material usually rubber, and reinforced with either wire and/or fabric. It is also made such that it can be mounted on a rim, and suitably constructed to retain air; with or without tube.

1.1 NEW TYRE:-

A tyre which has neither been used nor subjected to a retreading operation.

2.2 DEFINITIONS RELATING TO TYRE STRUCTURE:-

Structure of a pneumatic tyre means the technical characteristics of the tyre's carcass. The following structures are distinguishable.

2.2.1 DIAGONAL OR BIAS OR CROSS–PLY:

A pneumatic tyre in which the ply cords that extend to the beads are laid at alternate angles, substantially less than 90 degrees to the centre line of the tread.

2.2.2 RADIAL PLY:

A pneumatic tyre in which the ply cords that extend to the beads are laid at an angle of substantially 90 degrees to the centre line of the tread, the carcass being stabilized by a circumferential belt comprising two or more layer of substantially inextensible cord material.

2.2.3 Bias–Belted or belted– Bias:-

A pneumatic tyre structure of bias ply (diagonal) type in which the carcass is restricted by a belt comprising two or more layers of substantially inextensible cord material laid at alternate angles close to those of the carcass.

2.3. Definitions Relating to the Main Components of the Tyre .

2.31 Bead.

The part of the tyre which is shaped to fit the rim. It has a core made of one or several essentially inextensible strands with the plies wrapped around the core.

2.3.2 Breaker.

An intermediate ply between carcass and tread.

2.3.3 Carcass.

The part of the pneumatic tyre other than the tread and the external rubber sidewalls which when inflated, bear the load.

2.3.4 Cord

The strands forming the fabric of the various components of the tyre carcass, plies, breakers, etc.

2.3.5 Ply

A layer of rubber — coated substantially parallel cords forming the tyre body.

2.3.5.1 Ply-rating.

An index of tyre strength used to identify a given tyre with its recommended maximum, permitted load, when used for a specific service. (Ply-rating does not necessarily represent the actual number of plies in a tyre).

2.3.6 Tread

That part of a pneumatic tyre which rolls along the ground. It protects the carcass against mechanical damage and contributes to ground grip.

2.3.6.1 Tread Rib.

A tread section running circumferentially around a tyre

2.3.6.2 Groove.

The space between two adjacent tread ribs.

2.3.7 Sidewall.

That part of a pneumatic tyre between the tread and the bead.

2.4 Definition Concerning the Dimensions of the Tyre.

2.4.1 Section Width.

The linear distance between the exteriorc of the sidewalls of an inflated tyre, exclusing elevations due to labelling decoration, or protective bands.

2.4.2 Overall Width.

The linear distance between the exteriors of the sidewalls of an inflated tyre, including elevations due to labelling, decorations or protective bands or ribs.

2.4.3 Maximum Overall (grown) Tyre Width in Service.

The overall width (2.4.2) plus

(a) Manufacturing tolerances;

(b) Tolerance for service growth.

2.4.4 Section Height.

A distance equal to half the difference between the outer diameter of the tyre and the nominal rim diameter.

2.4.5 Overall Diameter.

The diameter of an inflated tyre at the outermost surface of the tread.

2.4.6 Maximum Overall (grown) Tyre Diameter in Service.

The overall diameter (2.4.5) plus.

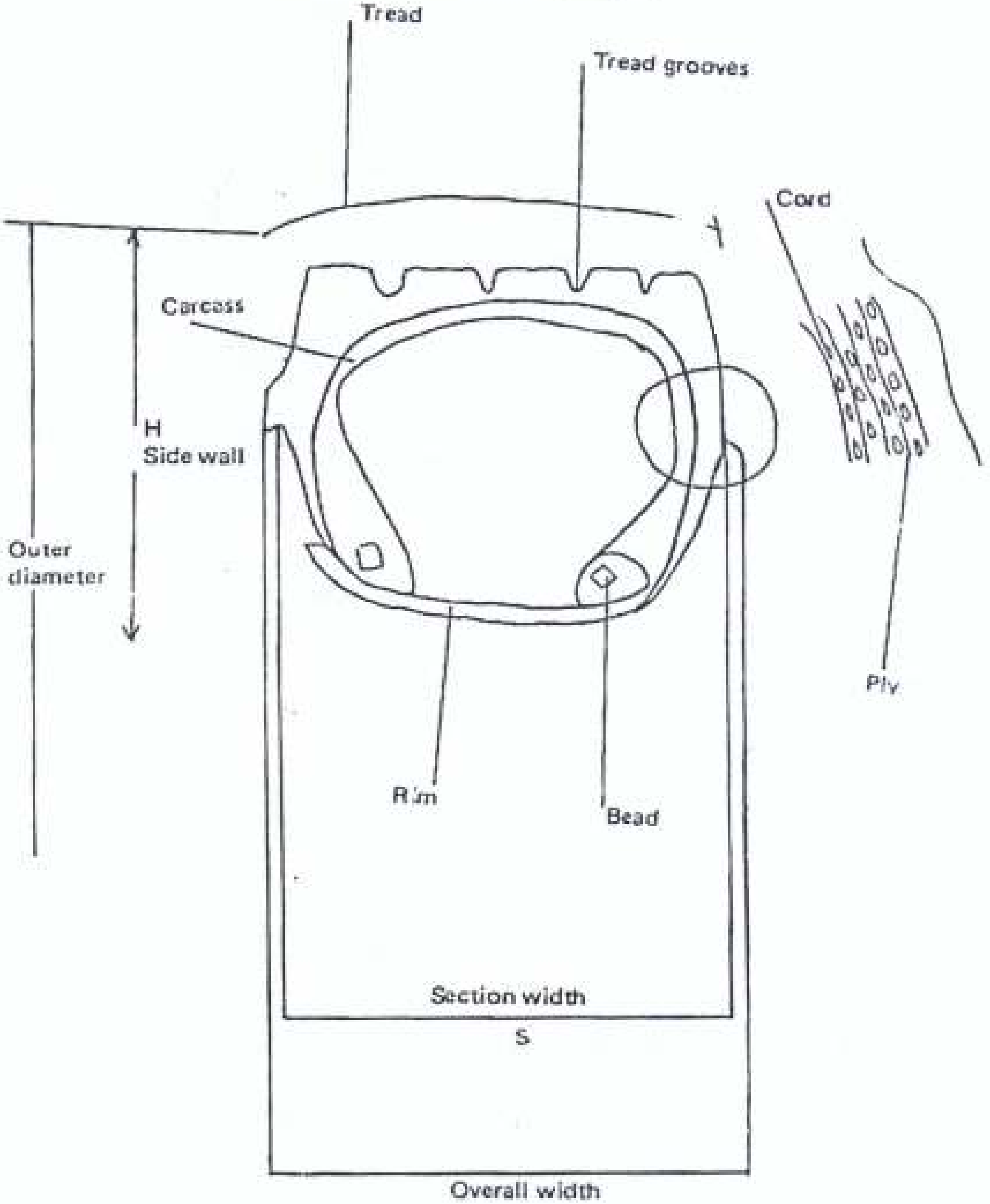
(a) Manufacturing tolerance;

(b) Tolerance for service growth.

2.4.7 Nominal Aspect Ratio.

One hundred times the ratio of the Section Height to the Section Width of the tyre on its test rim.

EXPLANATORY FIGURE 1



7

2.5 Other Definitions
The section• include other definitions not covered under 2.1, 2.2, 2.3 and 2.4.

2.5.1 Bead Separation.
A break down of bond between components in the bead area.

2.5.2 Chunking.
The breaking away of pieces of the tread.

2.5.3 Cord Separation.
Cord parting away from the banding rubber compounds.

2.5.4 Ply Separation.
A parting of rubber compound between adjacent plies.

2.5.5 Rim:
A support for a tyre or a tyre and tube assembly, upon which the tyre beads are seated.

2.5.6 Size Factor.
The sum of the Section Width and the outer diameter of tyre determined on the test rim.

2.5.7 Maximum Inflation Pressure.
The maximum cold inflation pressure to which a tyre shall be subjected.

2.5.8 Maximum Load Rating.
The load rating at the maximum permissible inflation pressure.

2.5.9. Load Index.
A numerical code associated with the maximum load a tyre can carry at the speed indicated by its speed symbol, under service conditions specified by the tyre manufacturer. (See Table 1).

TABLE 1 — LOAD INDICES

LOAD INDEX	CORRESPONDING TYRE LOAD KG	LOAD INDEX	CORRESPONDING TYRE LOAD KG.
50	190	86	530
51	195	87	545
52	200	88	560
53	206	89	580
54	212	90	600
55	218	91	615
56	224	92	630
57	230	93	650
58	236	94	670
60	250	95	690
61	257	96	710
62	265	97	730
63	272	98	750
64	280	100	800
65	290	101	825
66	300	102	850
67	307	103	875
68	315	104	900
69	325	105	925
70	335	106	950
71	345	107	975
72	355	108	1000
73	365	109	1030
74	375	110	1060
75	387	111	1090
76	400	112	1120
77	412	113	1150
78	425	114	1180
79	437	115	1215
80	450	116	1250
81	462	117	1285
82	475	118	1320
83	487	119	1360
84	500	120	1400
85	515		

2.5.10 Speed Code.

A symbol (letter) indicating the speed at which the tyre can carry a load corresponding to its load index, under service conditions specified by the tyre manufacturer. The nominal speed categories are shown in Table 2.

TABLE 2 – CORRELATION BETWEEN SPEED CODE AND SPEED CATEGORY.

SPEED CODE	SPEED CATEGORY (Km/h)
F	80
G	90
J	100
K	110
L	120
M	130
N	140
P	150
Q	160
R	170
S	180
T	190
U	200
H	210
V	210

2.5.11 Tyre Size Designation.

A designation showing

(a) The nominal section width e.g. (165 or 175)

(b) The nominal aspect ratio where applicable (i.e. where it is less than 82 series see 2.5.18 e.g. 175.70/14 where 70 is aspect ratio.

(c) The nominal rim diameter code of 3-digit whole number (e.g. 365) or a 2-digit whole number.

In all cases the values expressed are in conventional units.

TABLE 3 – CORRELATION BETWEEN RIM DIAMETER CODE AND NOMINAL RIM DIAMETER.

RIM DIAMETER CODE	NOMINAL RIM DIAMETER mm
10	255
12	305
13	330
14	355
15	380
16	405

2.5.12 Cracking

Any parting within the tread, sidewall, or innerliner of the tyre extending to cord material.

2.5.13 Innerliner

The layer (s) forming the inside surface of a tubeless tyre that contains the inflating medium within the tyre.

2.5.14 Innerliner Separation.

The parting of the innerliner from cord material in the Carcass.

2.5.15 Open Splice.

Any parting at any junction of tread, sidewall, or innerliner that extends to cord material.

2.5.16 Tread Separation.

Pulling away of the tread from the tyre carcass.

2.5.17 Sidewall Separation.

The parting of the rubber compound from the cord material in the sidewall.

2.5.18. Series Tyres.

Tyres with a nominal height/width ratio of the value times 10^2, e.g. 70 series tyres are tyres with to nominal height and width ratio of 0.70.

3. REQUIREMENTS.

3.1 General:-

Each tyre shall conform to the following requirements.

(i) It shall meet the requirements specified in 3.2 of this standard for its tyre size designation, type, and maximum permissible inflation pressure;

(ii) The permissible loading recommended by the tyre manufacturer for the various inflation pressures shall not depart from those indicated in at least one of the publications listed below, which are current at the date of manufacture or any later date:-
The Tyre and Rim Association.
The Japan Automobile Tyre Manufacturer's Association;
The European Tyre and Rim Technical Organisation Inc;

Deutsches Institute fues Normung;
The Society of Motor Manufacturers and Traders Limited;
British Standards Institution;
Scandinavian Tyre and Rim Organisation;

(iii) The tyre shall have incorporated in it at least four treadwear indicators approximately equally spaced around the circumference of the tyre, each of which provides a visual indication when the tread in the vicinity of the indicator has a depth of 1.60 + 0.4)– 0.25)mm.

(iv) The tyre shall be uniform either in shape and thickness and be free from any harmful defects, such as flaw, blister, crack and foreign material.

(v) The minimum tread life of a tyre fitted to a vehicle in good condition shall not be less than 20,000km provided the tyre is used within the load, pressure and speed limits recommended by the tyre manufacturer.

3.2 Performance Requirements.

3.2.1 Test Sample.

Three tyres having identical characteristics when described according to the requirements of Section 4 (Marking) shall comprise the test sample which shall be used as follows:-

(i) One tyre shall be used for physical dimensions, and resistance to bead unseating tests (if tubleless) in sequence.

(ii) A second tyre shall be used for tyre endurance.

(iii) A third tyre shall be used for high speed performance.

3.2.2. Physical Dimensions.

Each tyre shall conform to each of the following requirements when measured in accordance with the procedure in Appendix A.

(i) Its actual section width and overall width shall not exceed the section width specified in one of the publications listed in Section 3.1 (ii) for its size designation and tyre by more than 7%.

(ii) The outer diameter of the tyre shall not differ from the values specified in one of the publication listed in 3.1 (ii) by more than ± 2% in case of ordinary (road type) tyres, or by more than – 2% and + 4% in case of heavy tread tyres.

3.2.3.1. Tubeless Tyre Resistance to Bead Unseating.

When a tubeless tyre that has a maximum inflation pressure other than 413 KN/m^2 is tested is accordance with App. B, the applied force required to unseat the tyre bead at the point of contact shall not be less than:

(a) 6.67 KN for tyres with a designated section width of less than 152mm.

(b) 8.90 KN for tyres with a designated section width of 152 mm or more, but less than 203mm;

(c) 11.12 KN for tyres with a designated section width of 203mm or more;

using the section width specified in one of the publications listed in 3.1 (ii) for the applicable tyre size designation and type.

3.2.3.2 When a tyre that has a maximum inflation pressure of 413 KN/m^2 is tested in accordance with App. B, the applied force required to unseat tyre bead at the point of contact shall not be less than:

(a) 6.67 KN for tyres with a maximimum load rating of less than 400 kg;

(b) 8.90 KN for tyres with a maximum load rating of 400 kg or more, but less than 636 kg,

(c) 11.12 KN for tyres within maximum load rating of 636kg or more using the maximum load rating specified in one of the publications listed in 3.1 (ii) for the applicable tyre size designation and type.

3.2.4.1 Tyre Endurance.
After completion of the laboratory test wheel on endurance test specified in Appendix C, there shall be no visual evidence of tread, sidewall, ply cord, innerliner, or bead separation, chunking, broken cords, cracking, or open splices.

3.2.4.2 The tyre pressure at the end of the test shall not be less than the initial pressure specified in Table 4.

3.2.5 High Speed Test.
After completion of the laboratory speed test specified in appendix D, there shall be no visual evidence of tread, sidewall, ply cord, innerliner or bead separation, chunking, broken cords, cracking, or open splices.

4. MARKING.
Each tyre shall have the marking referred to in this section (4.1 to 4.7) moulded on or into the tyre. The markings shall be clearly legible and located on one of both sidewalls of the tyre.

4.1 The tyre size designation as defined in item 2.5.12 of this standard.
4.2 An indication of the structure as follows;
4.2.1 On diagonal (bias—ply) tyres, no marking;
4.2.2 On radial-ply tyres, the letter "R" placed in front of the rim diameter marking, and in addition the word "RADIAL."
4.3 The speed code as defined in item 2.5.10.
4.4 The Load index as defined in item 2.5.9, and /or the maximum load rating for the type expressed in kg;
4.5 The word "TUBELESS" if the tyre is designed for use without an inner tube.
4.6 The date of manufacture in the form of a group of 3 figures, the first two showing the week and the last the year of manufacture, e.g. 367 reps 26th week of 1987. However, this marking may be affixed on only one sidewall.
4.7 The trade name and/or mark of the manufacturer.

5. NON-CONFORMING TYRES.

No tyre designed for use on passenger cars, whicn does not conform to all the requirements of this standard, shall be produced locally or imported into Nigeria, for commercial purposes.

6. TYRE AND RIM MATCHING INFORMATION:-

Each manufacturer of tyres shall ensure that a listing of rims that may be used with each type of tyre which he produces is provided to the public in one of the following forms:-

(a) Listed by manufacturer's name or brand name in a document furnished to dealers of the manufacturer's tyres, or to any person upon request.

(b) Contained in publication listed in Section 3.1 (ii).

For the purposes of this clause, each rim listing shall include dimensional specifications or a diagram of the rim; except that a listing compiled in accordance with paragraph (s) of this clause, need not include dimensional specifications or a diagram of a rim if the rim's dimensional specifications are sustained in each listing published in accordance with paragraph (b).

Information contained in a publication listed in paragraph (b) which includes general categories of tyres and rims by size designation, type of construction, and/or intended use, shall be considered to be manufacturer's information pursuant to this clause for the listed tyres, unless the publication itself or specific information provided according to paragraph (a) indicates otherwise.

APPENDIX A
PHYSICAL DIMENSIONS

PROCEDURE

A.1 Determine tyre physical dimensions under uniform ambient conditions as follows:-

(a) Mount the tyre in an appropriate test rim for the tyre sizeA designation and inflate it to the applicable pressure specified in Table 4.

(b) Condition it at ambient temprature for at least 24 hours.

(c) Read-just pressure to that specified in (a) above.

(d) Caliper the section width and overall width at six points approximately equally spaced around the tyre circumference

(e) Record the average of those measurements as the section width and overall width, respectively.

(d). Determine tyre outer diameter by measuring the maximum circumference of the tyre and dividing this by Pi (3.14).

TABLE 4 – TEST INFLATION PRESSURES KN/m^2

Maximum Permissible Inflation Pressure.	220	240	248	275	280	300	413
Pressure to be used in tests for physical dime-nsions, bead unseating, tyre endurance	165	180	193	220	220	180	350
Pressure to be used in test for highspeed performances.	206	220	234	260	260	220	400

NOTE:-
In appropriate tests pressures shall be established within ± 7.00 KN m^2 of the values specified for each appropriate test.

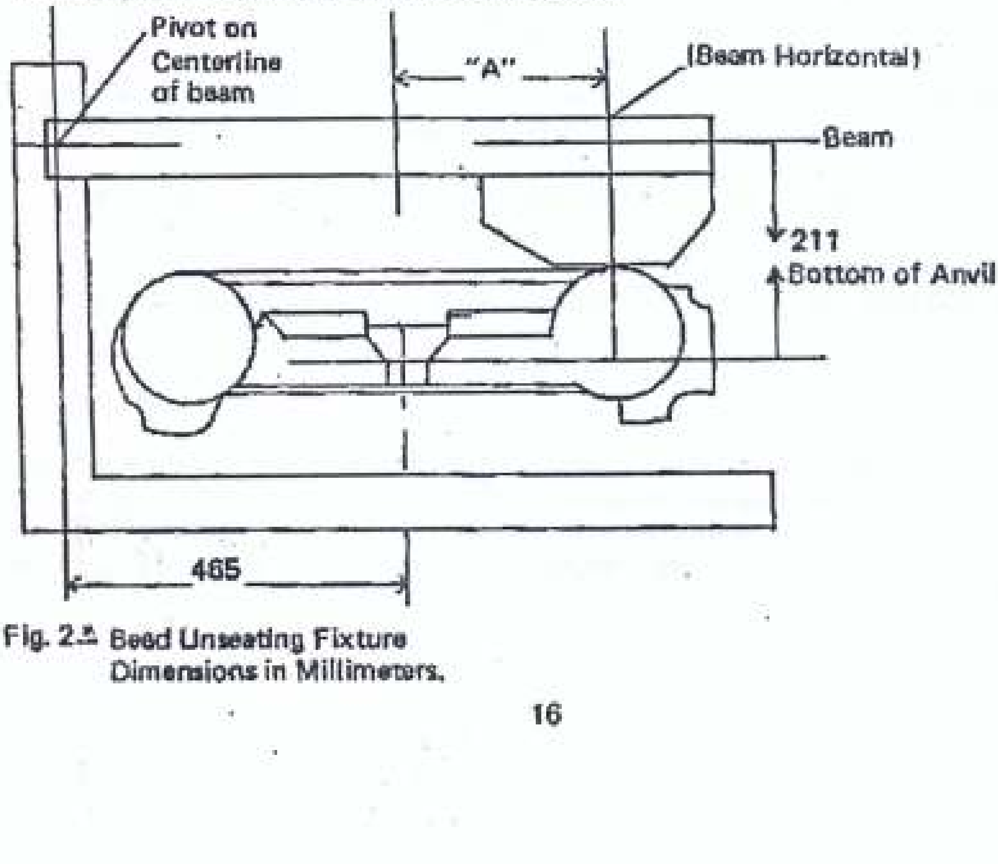


Fig. 2.* Bead Unseating Fixture
Dimensions in Millimeters.

TABLE 6

	TITLE:- DIMENSION "A" FOR TYRES WITH MAXIMUM INFLATION PRESSURE.	
WHEEL SIZE	Other than 413 kN/m^2	413 kN/m^2.
	306	
415	292	
406 (16)	292	251
390	279	
381 (15)	279	238
365	247	
356 (14)	266	226
340	228	
330 (13)	254	213
305 (12)	241	

APPENDIX B
RESISTANCE TO BEAD UNSEATING (FOR TUBELESS TYRES ONLY)

B.1 Wash the tyre, dry it at the beads and mount it without lubrication or adhersives on a clean, painted test rim.

B.1.3 Inflate it to the applicable pressure specified in Table 4 at ambient room temperature.

B.1.3 Mount the wheel and tyre in a fixture shown in Fig.2 and force the bead unseating block against the tyre sidewall.

B.2 Procedure:-

B.2.1 Apply a load through the block to the tyre outer sidewall at the distance specified in Fig. 2 for the applicable wheel size at a rate of 51 mm per minute, with the load arm substantialty parallel to the tyre and rim assembly at the time of engagement.

B.2.2 Increase the load until the bead unseats or the applicable value specified in 3.2.3 is reached.

B.2.3 Repeat the test at least four places equally spaced around the tyre circumference.

APPENDIX C
TYRE ENDURANCE

C.1 Preparation of Tyre on a test rim and inflate to the applicable pressure specified in Table 4.

C.1.2 Condition the tyre assembly to $30 \pm 3^{\circ}$ C for at least three hours.

C.1.3 Re-adjust tyre pressure to that specified in Table 4 immediately before testing.

C.2 Procedure:-

C.2.1. Mount the tyre and wheel assembly on a test axle and press it against a flat—face of a smooth wheel 1.7m to 2.0m ± 1% in diameter and at least as wide as the section width of the tyre to be tested or an approved equivalent test wheel, with the applicable test load specified in the table under C-2.3 for the tyre's size designation type, and maximum permissible inflation pressure

C.2.2. During the test, the air surrounding the test area shall be $30 \pm 3^{\circ}$C.

C.2.3 Conduct the test at 80 km/hr. in accordance with the following schedule without pressure adjustment or other interruption.

Test periods	Test load as percentage of maximum load rating.
4 hours	85
6 hours	90
24 hours	100.

C.2.4 Immediately after running the tyre for the required length of time measure its inflation pressure. Allow the tyre to cool for one hour. Then deflate the tyre; remove it from the test rim, and inspect it for the conditions specified in 3.2.4.1.

APPENDIX D.

PROCEDURE FOR HIGH SPEED PERFORMANCE TESTS

D.1 After preparing the tyre in accordance with C.I. mount the tyre and wheel assembly in accordance with C.2.1 .and press it against the test wheel with the load of 80% of the tyre's maximum load rating as marked on the tyre's maximum load rating marked on the tyre side wall.

D.2 Break in the tyre by running it for 2 hours at 80Km/hr.

D.3. Allow to cool to 30 ± 3^oC and readjust the inflation pressure to the applicable pressure specified in Table 4.

D.4 During the test the temprature in the test room must be maintained at the 30 ± 3^oC.

D.5 Carry the test through, with interruption not more than 2 mins. for temprature checks, in conformity with the following particulars:-

D.5.1 Time taken to pass from zero speed to initial test speed 10 minutes;

D.5.2 Initial tests prescribed maximum speed for the type of tyre less 40 Km/hr in the case of the smooth wheel having 1.7m ± 1% diameter or less 30 Km/hr. in the case of the smooth wheel having 2m ± 1% diameter.

D.5.3 Successive speed increments: 10km/hr.

D.5.4 Duration of test at each speed step except the least 10 minutes;

D.5.5. Duration of test at last speed step 20 minutes.

D.5.6 Maximum test speed: prescribed maximum speed for the type of tyre less 10 Km/hr. in the case of the smooth wheel having 1.7m ± 1% diameter or equal to the prescribed maximum speed in the case of the smooth wheel having 2m + 1% diameter.

D.6 Immediately after running the tyre for the required time, measure its inflation pressure, Allow the tyre to cool for one hour. Then deflate the tyre, remove it from the test rim and inspect it for the conditions specified in 3.2.7.

APPENDIX F
GENERAL NOTES

1.1 TYRE MARKING

TABLE 6

EXAMPLES OF TYRE MARKINGS	NOMINAL SECTION WIDTH	NOMINAL ASPECT RATIO (%)	TYRE CONSTRUCTION	NOMINAL RIM DIAMETER CODE
185/60*R15	185mm	60	Radial	14
205/70*R15 or ER/70*R15	205mm	70	Radial	15
185*R14	185mm	82	Radial	14
6.40*R13	6.4'.	95	Radial	13
6.40*13	6.4''	95	Diagonal	13
185*47*–35* 14 or 7.35*14–35* 14 or 185*14 or 7.35*14.	185mm or 7.35''	82	Diagonal	14