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EFFECTIVENESS OF TREAD DEPTH PATTERN OF OLD AND NEW MOTORBIKES AT VARIOUS SPEEDS OVER THE SOIL SURFACE

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ABSTRACT

Vehicles especially motorbikes have become a common asset for criminals to be used in various crimes, such as abduction, robbery, burglary, murder, etc. In the present study, a total of 20 (10 with new tyre and 10 with old tyre) motorbikes was used to engender their tyre impression. The samples of the tyre impression were collected by riding double each motorbike at seven different speeds over the soil surface at the village Basari, Jhansi (Uttar Pradesh). The riding surface was composed of medium black and red soil with temp 34 °C. Riding double includes the driver weight 58 kg together with pillion driver weight 52 kg and was kept uniform throughout the study. The depth of the tyre impression was measured using a taper gauge and it was found that tyre tread depth of both new and old tyres depends on the speed as well as on the weight of the motorbikes. It was concluded that there is a statistically significant difference in the tyre tread depth pattern produced by old and new motorbikes of the same make and model.

Keywords: Forensic Science, Tyre Impression, Tyre Tread Depth, Motorbikes, Soil, Gross Weight.

INTRODUCTION

Earlier vehicles were the simple mechanical devices used to transport people rather than goods. Later, with the passage of time, many definitions of vehicles were developed to meet people's comfort, speed, and needs. Modern vehicles are complex machines accompanying technological advancements to meet safety, security, comfort, and speed. Motorbikes include mopeds, scooters, sportbikes, and many other types of vehicles that run over roads, seat one to two people, and have two wheels. Two-wheeler motorbike especially sportbike is very popular among youth and their use is likely high in cases involving young criminals.

The use of vehicles in criminal activities has always been a support for criminals. Motor vehicles are involved not only in ordinary crimes such as runaway, theft, violence, and snatching, but also in heinous crimes such as murder, abduction, suicide and terrorism. In criminal cases motor vehicles are frequently involved coming in and going away from the place of crime [1].

Every vehicle is composed of a rubber covering material known as tyre, which is typically inflated or surrounding an inflated inner tube, placed around a wheel to form a soft contact with the road. Tyres are the only components of the vehicle that make contact with the road and serve as a means to support the vehicle's weight and road traction. They also absorb and control the forces of the road surface, thereby balancing the dynamics of the vehicle during its motion.

A tyre is round when it is not under load. When a tyre is placed on a vehicle under load, the portion

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of the tyre having contact with the road surface flattens. The flattened area that makes contact with the road is called 'tyre's footprint' or 'contact patch' [2]. The length of the tyre footprint increases as tyre inflation decreases or the load increases [3]. The tyre indentation pattern image of the same tyre encompasses some similarities and dissimilarities to its surface pattern image due to class characteristics and wear-and-tear [4]. Enlarged photography and detailed analysis of tyre impressions can lead to positive identification of the alleged vehicle in cases of crossover tyre impressions [5].

The tyre prints present at the crime scene can reveal a lot of information about the vehicle. It can help to recreate the crime scene and the modus operandi. Tyre prints are an important part for the study of accident cases. The tyre impressions left by the vehicles can be of valuable evidence in narrowing down the type of vehicle involved, the route adopted before and after, and the speed of motorbike at the commission of the crime [6].

MATERIALS AND METHODOLOGY

The present research work tested the hypothesis whether there is a significant difference between the old and new tyre tread depths involving the gross weight and speed of motorbikes. Observations were taken by measuring the depth of tyre impression formed on the soil surface.

Hypothesis

Null Hypothesis (H_0)- There is no difference in the tyre tread depth old and new motorbikes of same make and model.

$$H_0: \mu 1 = \mu 2$$

Alternative Hypothesis(H_1)- There is difference in the tyre tread depth among old and new motorbikes of same make and model.

$$H_1: \mu 1 \neq \mu 2$$

Where, **μ1** = population mean of new tyre tread depth

μ2 = population mean of old tyre tread depth

In the present study, a total of 20 motorbikes of different make and models involving 10 new and 10 old tyres as shown in table 1 were utilized. The age of the tyres was decided on the basis of reading observed on the odometer of their respective motorbikes. Tyre ran less than 300 kms were considered new whereas those that ran more than 1000 kms were considered old.

Site Selection

Samples of tyre impressions were taken on a plain soil track in the village Basari, tehsil Tahrauli in Jhansi, Uttar Pradesh. The soil surface was used for sampling, which consists of a mixture of medium black soil and red soil. This type of soil is very abundant in Bundelkhand Region and develops in a warm temperate climate having thin organic matter, low in nutrients, humus and less water holding capacity. Color of the soil varied from brownish black to reddish brown black. At the time of sampling, temperature was at about 34° C. Sampling just after the rain was avoided due to wetting of soil, as it would hamper the depth of tyre impression.



Figure 1: Image of site used for recording tyre tread depth measurement

Sampling Procedure

Motorbikes were ridden by a rider (58 kg) together with a pillion rider (52 kg) sitting straight on the motorbike. Both the riders used each motorbike at seven different speeds (10, 20, 30, 40, 50, 60 and 70 Km/h) to create tyre impressions over the soil surface. For each motorbike, three readings of tread depth from three different locations of tyre impression were measured using a taper guage and their average was used for the analysis. The riders were kept similar and the same procedure was adopted for taking the measurements for all the 20 motorbikes.



(a) (b)

Figure 2: (a) Double riding and (b) Tyre impression of a motorbike

Table 1: Different brands of motorbikes along with their run

S. No.	Company	Model	Old Tyre Used (In Km)	New Tyre Used (In Km)
1	Hero MotoCorp	HF Deluxe	1400	250
2	TVS Motors Company	Star City	1600	200
3	Bajaj Auto Limited	Discover 125M	1300	250
4	Hero MotoCorp	Splendor	1500	150
5	TVS Motors Company	Sports	1500	200
6	Bajaj Auto Limited	CT 100	1600	280
7	Honda Motors Ltd.	Activa 4G	1200	240
8	TVS Motors Company	Apache RTR160	1400	270
9	Royal Enfield Motors Ltd.	Classic350	1200	250
10	Honda Motors Ltd.	Shine	1500	290

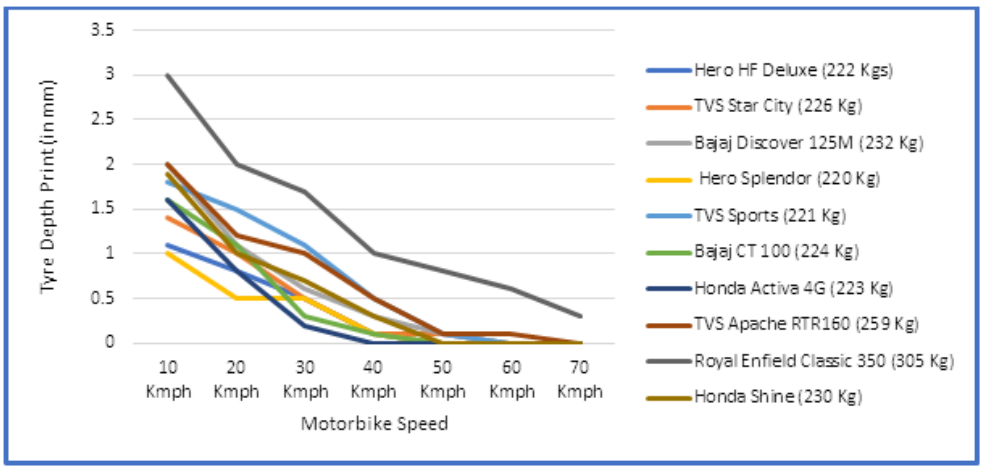
RESULTS

Curb weights of new and old motorbikes belonging to the same make and model were considered identical. The gross weight was calculated by adding the total weight of the two riders and the curb weight of the motorbike as shown in Table 2.

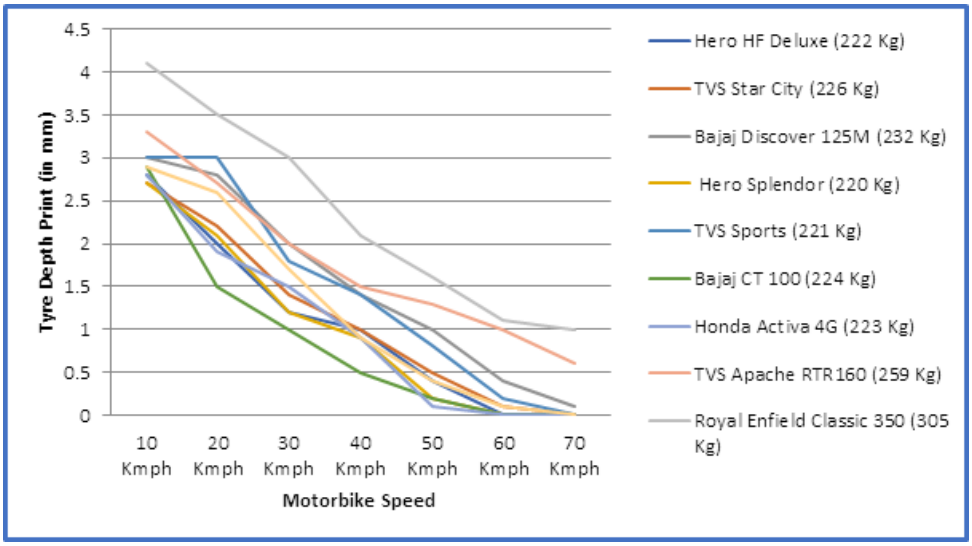
Table 2: Gross and curb weights of different motorbikes

S. No.	Motorbike Models	Curb Weight (In kg)	Weight of Two Passengers	Gross Weight (In kg)
1	Hero HF Deluxe	112	110	222
2	TVS Star City	116	110	226
3	Bajaj Discover 125M	122	110	232
4	Hero Splendor	110	110	220
5	TVS Sports	111	110	221
6	Bajaj CT 100	114	110	224
7	Honda Activa 4G	113	110	223
8	TVS Apache RTR160	149	110	259
9	Royal Enfield Classic350	195	110	305
10	Honda Shine	120	110	230

Graph 1: Variations in tyre tread depth produced by various old tyre motorbikes at different speeds



Graph 2: Variations in tyre tread depth produced by various new tyre motorbikes at different speeds



The weight and the speed of a motorbike play an important role in the determination of tyre tread depth. Graphs 1 and 2 are showing the trend of the tread depth pattern of old and new motorbikes at different speeds respectively. It is observed that if motorbikes were of higher weight the depth of tyre impressions was also deeper.

Depth of Tyre Impression $\propto$ 1 / Speed of Vehicle _____ (1)

Statistics

All the data collected in the present study were tested statistically. The descriptive statistics of all the parameters used has been shown in table 5. Pearson's correlation and Normality tests are used to check the correlation and spread of data and their results have been shown in tables 6 and 7 respectively. Non-parametric, Mann-Whitney U test is applied to test the hypothesis and the results are shown in tables 6 and 7.

Table 3: Descriptive statistics of variables studied

	N	Minimum	Maximum	Mean	Standard deviation
Speed	10	10	70	40	21.60
Old Tyre Tread Depth	70	0	3.0	.5814	.6895
New Tyre Tread Depth	70	0	4.10	1.3429	1.114
Gross Weight of Motorbike (In kg)	10	220	305	236.20	26.73
Old Tyre Used on the basis of Run	10	1200	1600	1420	147.57
New Tyre Used on the basis of Run	10	150	290	238	42.89

Table 4: Pearson correlation between speed and tyre tread depth

Pair	N	Pearson Coefficient	Significance
Tyre Depth Print of Old Tyres – Speed	70	-.871	.00
Tyre Depth Print of New Tyres – Speed	70	-.734	.00

Table 6 represents the relationship between speed and tyre tread depth. The Pearson's Correlation between the old tyre tread depth and speed was found to be -.871 which shows a fairly strong negative correlation. Again, the Pearson's Correlation between the new tyre tread depth and speed was found to be -.734 which shows a fairly strong correlation. Correlation is significant at the level of 0.01 (2 Tailed). Irrespective of the age of tyre, an inverse relationship was observed between speed and the tyre tread depth, which means the depth of tyre impression decreases with the increase of speed.

Table 5: Normality test of tyre tread depths

	Kolmogorov–Smirnov			**Shapiro–Wilk**		
	Statistics	*df*	*Significance*	*Statistics*	*df*	*Significance*
Tyre Tread Depth	.168	140	.000	.866	140	.000

Table 7 represents Kolmogorov – Smirnov test which indicates that the tyre depth prints did not follow a normal distribution (D (140) = 0.168, $p < 0.05$). As the data were not normally distributed, a non-parametric counterpart of Independent t-test i.e., Mann-Whitney U Test was applied to test the hypothesis.

Table 6: Rank statistics of Mann-Whitney U test

	Motorbikes	N	Mean Rank	Sum of Ranks
Tyre Tread Depth	Old Tyre	70	56.38	3946.50
	New Tyre	70	84.62	5923.50
Total		140		

Table 8 indicates that the new tyre motorbikes produce higher tyre tread depth having a mean rank of 84.62 than that of the old tyre motorbike having a mean rank 56.38.

Table 7: Test statistics of Mann-Whitney U test

	Tyre Tread Depth
Mann - Whitney U Test	1461.500
Wilcoxon W	3946.500
Z	-4.153
Asymp. Sig. (2- tailed)	.000

From table 9 Mann-Whitney U test, it is clear that there is a significant difference between the old and new tyre tread depth (**U** = 1461.50, **p** < .05). A p-value less than 0.05 is statistically significant. Hence, we fail to accept the null hypothesis which means there is a significant difference in tyre tread depth produced by old and new motorbikes.

DISCUSSION

The present research work focuses on the examination of tyre tread depth formed on the soil surface at different speeds. On the basis of statistical analysis of results, it is concluded that the old and new motorbike tyres of the same make and model will produce different tread depth patterns over the soil surface. Two-wheeler motorbikes were selected for the study as these are the first choice of youth and easy to go through a crowded or narrow route where the three or more wheelers fail to pass. India is agricultural land, mostly covered with soil which is extended to forests and most of the barren lands.

Most of the crimes take place outdoor and there is a likely possibility of finding tyre impressions which could lead to the identification of motorbikes used. It was observed that the weight of the motorbike and their speed significantly contribute to the tyre tread depth. It was also recorded that the air pressure in the tyre and type of soil also affects the formation of tyre impressions. ***Burt et al.*** (1992) researched the compaction of soil through tyre contact pressure and concluded tyre pressure as a great factor for tyre prints formation [7]. ***Sledge et al.*** (1997) derived a mathematical formula for the calculation of speed of the vehicle using yaw marks [8].

Furthermore, there is an urgent need to develop a test setup for the holistic study of various factors and physical parameters that govern the formation of tyre impression on a surface, to better address and elicit the facts involving vehicles in crime.

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