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Determination of Calibre of Fired Bullets from its Distorted Base

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Abstract: ***Every day we hear or read the news of suicide, murder, kidnapping, extortion and shooting incidents. Criminals are using different types of firearms including country/improvised pistols to commit crimes. They may use to fire at human, non-human beings and solid materials. In many shooting cases, Trigonometry and Geometry often provide the mathematical bases for the solutions. It is quite common to find bullets at place of shooting occurrence during the course of crime scene investigation. For the purpose of reconstructing a shooting scene, Crime scene manager or ballistic expert may be able to identify the source of each bullet traced. The bullets recovered at shooting incidents are generally distorted and/or fragmented; hence determination of calibre is very difficult. The distorted bullet base takes a normally oval shape. However, shape of bullets can vary considerably from bullet to bullet. In this paper authors have estimated the calibre of bullet by measuring the long and short axes of the oval shaped base of bullet. In present study a mathematical calculation for 9mm, .32", .380'', .303'', 5.56x45mm, 7.62x39mm and 7.62x51mm bullets have been scientifically elaborated.***

Keyword: Standard weapon, distorted bullets, shooting incidents, Trigonometry

1. Introduction

When the bullet passes through the barrel, the rifling will tear off small fragments of the bullet. Some of these fragmentations will remains in the bore and others will be blown out of the bore by the gases following the bullet. When the bullet passes through any target material, whether it is human flesh, fabric, glass sheets, walls or plank of wood, these fragments are frequently transfers to the medium through which it is passed.

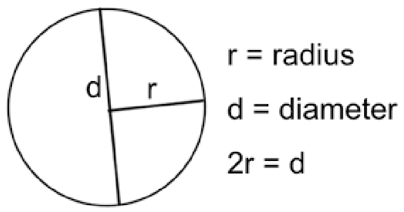
It is general perception that when a bullet passing through glass, experience a large deviation from its normal flight path. A work done reported on relatively small deviation [1-3]. The Behaviour of Bullets fired through glass explained [4].On the other hand explanations reports of effect on tempered glass by bullet trajectory explained [5].Reported the measurement of bullet deflection by intervening objects and a study the bullet behaviour after impact [6]. The penetration of auto body parts during vehicle shootings was described [7]. A report on estimation of Bullets diameter using the bullet hole identification kit (BIK) also reported [8]. The remaining velocity of bullets fired through different glass plates has been studied [9]. The perforation craters have always as well defined shape with more or less constant semi angle which was independent of the projectile calibre, velocity and thickness of target material has also interpreted [10].

2. Methods and Materials

To estimate the calibre of distorted bullets, .303", AK47, 7.62 SLR, and 5.56 INSAS Rifles were used as high velocity rifles. .32" calibre pistol, 9mm pistol, .380" Revolver was used as low velocity weapons with respective ammunition. They were used for test firing through different target materials such as Glass targets, acrylic sheets, Bakelite sheet, Steel plates and solid brick. Distorted or partially fragmented bullets were recovered from the bullet recovery box in the laboratory. To estimate the diameter of distorted bullet base, below mentioned formula have been applied for calculation of perimeter of an oval, which provides a means of calculating bullet diameter (i.e. calibre of distorted bullet). The perimeter of an oval "P" is closely approximated using the formula:

$$P = \prod \sqrt{[2(a^2+b^2) - ½(a-b)^2]}$$

Here, we know that the perimeter of a circle is found by multiplying the diameter "d" by a constant which is designated as "Pi" (i.e. ∏ **):**



$P = \prod d$

[Diameter of circle = Twice the radius]

d=2r

Circumference of the circle = $\prod d = \prod \times 2r = 2\prod r$

Here, from the above equation, we can derive the formula for the diameter of the circle, represented by the oval.*

Diameter of the circle (oval) = $\sqrt{[2(a^2+b^2) - ½(a-b)^2]}$

$X = 2(a^2+b^2)$

$Y = ½(a-b)^2$

For better illustrations, we can show the diagram as:

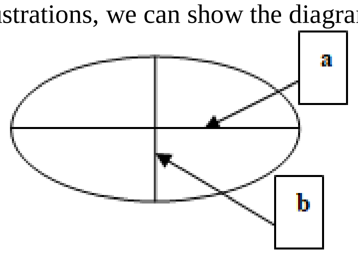


Figure 1: One half of long and short axes.

Where, a = ½ long axis; b = ½ short axis

Here, we assumed that idealized diameter of oval equates to the calibre of the distorted bullet. Here calibre is the distance between cross sectioned internal diameter of land to land. The values of “a” and “b” are one half of the long and short axes respectively. (Please refer to Fig. 1).

It is a practical approximation of calibre for flattened / distorted (oval) bullets and its fragments may be calculated from the long and short axes of the bases. It is observed that jacketed bullets tend to yield results closer to the actual calibre than non-jacketed bullets.

3. Result and Discussion

Analysis of table 1 showed that the practical approximation of distorted calibre of bullets for:

a) 9mm standard bullet is **9.075**mm calibre.
b) 5.56x45mm calibre bullet is **5.609** mm calibre.
c) .380” standard bullet is **.384”**calibre.
d) .32” slandered bullet is **.338”**calibre.
e) 7.62 x 39mm (AK47) standard bullet is **7.861**mm calibre.
f) 0.303” standard bullet is **.320”** calibre.
g) 7.62 x 51mm (SLR) standard bullet is **7.892**mm calibre.

A best suited oval shaped bullet at base measurement was approximated for the partially fragmented bullet base. Distorted bullets were estimated approximately from the long and short axes of the base of projectiles/bullets (Refer fig. 1, 2 & 3).

It is also revealed that, jacketed bullets tend to yield results closer to the actual calibre of the bullet than the non-jacketed bullets. It is not possible to approximate lead cores fired through glass or intermediate targets as its base are generally deformed and hence not considered for calculation of calibre. The lead element is easily available in the nature, easy to fabricate, low melting point and high density among the other periodic elements. Hence fully lead bullet/semi jacketed bullets are easily deformed after hitting on hard surfaces including bones etc.

4. Conclusion

Estimation of calibre of distorted/fragmented bullets showed reasonable approximation as compared with standard bullet base. In any circumstance, Forensic Ballistics expert and crime scene manager must remember that the estimated value (by formula obtained) was an approximation only and should be treated as such. For determination of distorted bullets from the base more amounts of data is required for calculation and interpretation. The suggested equation is suggestive and indicative only. It is observed that approximate estimation of distorted bullets in the laboratory condition given as 9 mm standard bullet is approximated as 9.075 mm.

5. Acknowledgement

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Table 1: Collected Data of Distorted Projectiles of Various Calibres

Bullet	a (mm)	b(mm)	a^2(mm)	b^2(mm)	(a-b) (mm)	Y={(a-b)^2}/2 (mm)	X=2(a^2+b^2) (mm)	√X-Y mm/inch (units given as per nomenclature of calibre)
9mm	4.785	4.65	22.896	21.622	0.135	0.00911	89.036	9.435
9mm	4.515	4.43	20.385	19.624	0.085	0.0036	80.018	8.945
9mm	4.515	4.44	20.385	19.713	0.115	0.01322	79.490	8.915
9mm	4.524	4.41	20.466	19.448	0.114	0.0064	79.828	8.934
9mm	4.522	4.44	20.448	19.713	0.082	0.0036	80.322	8.9620
9mm	5.014	4.42	25.140	19.536	0.594	0.1764	89.352	9.4432
9mm	4.735	4.15	22.420	17.222	0.585	0.1711	79.284	8.894
							Mean	**9.075**
5.56mm	2.85	2.745	8.1223	7.535	0.105	0.01102	31.3152	5.594
5.56mm	2.86	2.765	8.1796	7.645	0.095	0.00902	31.6496	5.624
5.56mm	2.78	2.775	7.7284	7.700	0.005	0.00002	30.8583	5.554
5.56mm	2.84	2.773	8.0656	7.672	0.072	0.00492	31.4774	5.615
5.56mm	2.81	2.755	7.8961	7.59	0.055	0.00302	30.9722	5.564
5.56mm	2.86	2.773	8.2082	7.672	0.095	0.00902	31.7622	5.634
5.56mm	2.92	2.722	8.5264	7.398	0.234	0.04342	31.8496	5.643
5.56mm	2.92	2.575	8.5264	6.630	0.345	0.11902	30.3144	5.504
5.56mm	3.15	2.565	9.9225	6.553	0.594	0.34813	32.9522	5.714
5.56mm	2.83	2.856	8.0372	7.84	0.035	0.00122	31.7544	5.634
5.56mm	2.88	2.695	8.2944	7.263	0.185	0.03422	31.1148	5.574
5.56mm	3.42	2.215	11.7302	4.906	1.211	1.46402	33.2736	5.639
5.56mm	3.44	2.245	11.8681	5.042	1.223	1.4431	33.8161	5.689
5.56mm	3.22	2.245	10.3683	5.043	0.975	0.95061	30.8168	5.464
5.56mm	2.84	2.735	8.0650	7.480	0.105	0.01102	31.0916	5.574
5.56mm	2.86	2.795	8.1796	7.812	0.065	0.00422	31.9832	5.654
5.56mm	3.70	1.890	13.7271	3.572	1.815	3.29422	34.5982	5.594
5.56mm	2.92	2.625	8.5264	6.890	0.295	0.08702	30.8342	5.544
5.56mm	2.96	2.795	8.7912	7.812	0.173	0.01445	33.20645	5.761
							Mean	**5.609**
.380”Rev	4.085	4.765	23.590	22.705	0.092	0.0042	92.590	9.62/.378

.380"Rev	4.932	4.831	24.324	23.338	0.101	0.0051	95.324	9.76/.384
.380"Rev	4.940	4.837	24.4036	23.396	0.103	0.0053	95.59	9.77/.384
.380"Rev	4.890	4.861	23.912	23.522	0.39	0.076	94.869	9.73/.383
.380"Rev	4.956	4.845	24.561	23.474	0.111	0.0061	96.070	9.75/.383
.380"Rev	4.971	4.862	24.710	23.639	0.109	0.0059	96.698	9.83/.387
.380"Rev	4.976	4.859	24.760	23.609	0.117	0.0068	96.739	9.83/.387
.380"Rev	4.983	4.876	24.830	23.775	0.107	0.0057	97.210	9.859/.387
.380"Rev	4.913	4.843	24.137	23.454	0.07	0.0024	95.182	9.75/.383
							Mean	**9.76 /.384"**
0.32Rev	4.87	3.223	23.716	10.3684	1.653	1.3612	68.1706	8.173/.321
0.32Rev	4.682	3.985	21.902	15.8802	0.695	0.2415	75.5652	8.679/.341
0.32Rev	5.205	4.244	27.092	18.0243	0.964	0.4608	90.2241	9.474/.372
0.32Rev	4.405	3.855	19.404	14.8612	0.555	0.1512	68.53005	8.269/.325
0.32Rev	4.253	3.885	18.062	15.0932	0.365	0.06661	66.3114	8.139/.320
0.32Rev	4.524	4.41	20.466	19.448	0.114	0.0064	79.828	8.934/.351
							Mean	**8.61/.338"**
AK47 (7.62mm)	3.975	3.865	15.8006	14.9382	0.112	0.0060	61.477	7.843
AK47 (7.62mm)	4.295	3.652	18.4471	13.3223	0.645	0.2080	63.539	7.952
AK47 (7.62mm)	3.962	3.8234	15.6816	14.4454	0.162	0.0128	60.243	7.765
AK47 (7.62mm)	3.965	3.795	15.7212	14.4023	0.173	0.0144	60.246	7.763
AK47 (7.62mm)	3.975	3.884	15.8006	15.0544	0.095	0.0045	61.713	7.855
AK47 (7.62mm)	3.975	3.815	15.8006	14.5542	0.162	0.0128	60.709	7.791
AK47 (7.62mm)	4.122	3.805	16.9744	14.4782	0.315	0.0496	62.904	7.928
AK47 (7.62mm)	3.985	3.835	15.8802	14.7072	0.153	0.0112	61.174	7.821
AK47 (7.62mm)	3.975	3.835	15.8006	14.7072	0.143	0.0098	61.015	7.811
AK47 (7.62mm)	3.975	3.835	15.8006	14.7072	0.145	0.0098	61.015	7.811
AK47 (7.62mm)	3.973	3.834	15.7609	14.6689	0.146	0.0098	60.859	7.834
AK47 (7.62mm)	4.565	3.565	20.8392	12.7092	0.143	0.5564	67.096	8.161
							Mean	**7.861**
.303"	3.992	3.842	15.920	14.7456	0.152	0.0112	61.331	0.308"
.303"	3.975	3.762	15.800	14.1376	0.215	0.0231	59.876	0.304"
.303"	4.821	3.265	23.041	10.6602	1.535	1.1781	67.400	0.320"
.303"	3.915	3.825	15.327	14.6306	0.092	0.0042	59.915	0.304"
.303"	4.205	3.974	17.682	15.7609	0.235	0.0276	66.885	0.301"
.303"	4.152	3.495	17.222	12.1801	0.663	0.2178	58.805	0.305"
.303"	4.155	3.033	17.264	9.1809	1.123	0.6328	52.889	0.345"
.303"	4.775	2.652	22.800	7.0225	2.12	2.2578	59.646	0.365"
.303"	4.123	3.755	16.813	14.1342	0.343	0.0595	61.824	0.341"
.303"	4.355	3.855	18.966	14.8611	0.545	0.1253	67.654	0.321"
.303"	4.355	3.855	18.966	14.8612	0.545	0.1254	67.654	0.312"
.303"	4.205	3.973	17.682	15.7609	0.234	0.0276	66.885	0.370"
.303"	4.154	3.494	17.222	12.1801	0.665	0.2178	58.805	0.301"
.303"	4.156	3.755	16.813	14.1231	0.344	0.0595	61.825	0.309"
.303"	4.045	3.595	16.362	12.9241	0.455	0.1012	58.572	0.301"
							Mean	**0.320"**
SLR (7.62 mm)	3.92	3.883	15.366	15.0544	0.042	0.0008	60.8416	7.834
SLR	4.87	3.223	23.716	10.3684	1.653	1.3612	68.1706	8.173
SLR	3.92	3.815	15.213	14.5542	0.085	0.0036	59.5284	7.715
SLR	3.873	3.815	14.976	14.5542	0.055	0.00151	59.0622	7.685
SLR	3.895	3.814	15.171	14.5161	0.085	0.00361	59.3742	7.705
SLR	3.905	3.834	15.249	14.6689	0.075	0.00281	59.8358	7.735
SLR	4.145	3.583	17.181	12.8164	0.565	0.1596	59.9948	7.735
SLR	3.924	3.785	15.366	14.3262	0.135	0.0091	59.3852	7.706
SLR	4.095	3.855	16.769	14.8613	0.242	0.0288	63.26005	7.952
SLR	3.995	3.581	15.963	12.8164	0.415	0.0861	57.5528	7.581
SLR	3.965	3.883	15.721	15.0544	0.085	0.00361	61.5512	7.845
SLR	4.073	3.675	16.564	13.5056	0.395	0.07801	60.1412	7.753
SLR	4.682	3.985	21.902	15.8802	0.695	0.2415	75.5652	8.679
SLR	4.414	3.335	19.448	11.0889	1.083	0.5832	61.0741	7.778
SLR	3.955	3.886	15.642	15.0544	0.075	0.0028	61.3928	7.835
SLR	3.875	3.842	14.745	15.0156	0.035	0.0061	59.5224	7.715
SLR	4.005	3.743	16.042	13.9876	0.265	0.0351	60.0552	7.748
SLR	5.205	4.244	27.092	18.0243	0.964	0.4608	90.2241	9.474
SLR	4.245	3.255	18.023	10.5625	0.995	0.4950	57.1652	7.528
SLR	4.234	3.683	17.892	13.5424	0.554	0.1512	62.8706	7.919
SLR	4.405	3.855	19.404	14.8v612	0.555	0.1512	68.53005	8.269
SLR	3.955	3.775	15.642	14.2506	0.183	0.0163	59.78525	7.731

SLR	4.024	3.845	16.160	14.4423	0.224	0.0242	61.2008	7.822
SLR	3.955	3.824	15.642	14.5924	0.135	0.0091	60.4688	7.776
SLR	3.935	3.794	15.484	14.3641	0.145	0.0105	59.6966	7.726
SLR	4.253	3.885	18.062	15.0932	0.365	0.06661	66.3114	8.139
SLR	4.085	3.633	16.687	13.1769	0.455	0.10351	59.7282	7.722
SLR	3.923	3.785	15.366	14.3262	0.135	0.00911	59.3852	7.706
							Mean	**7.892**

Figure 2: Showed the distorted bullets of **7.62x51(SLR)** mm and **.303"** calibre.

Figure 3: Showed the distorted bullets of **9mm** and **7.62x39 (AK-47) mm calibres**

Figure 4: Showed the distorted bullets of .380" **calibre**

6. Acknowledgement

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