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14. ABSTRACT

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Does Polishing a Rifle Bore Reduce Bullet Drag?

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Abstract

The experiment reported in this article addresses whether polishing a rifle bore reduces the aerodynamic drag of bullets. It was hypothesized that by polishing a rifle bore the aerodynamic drag of bullets would be reduced because a smoother bore would result in smoother rifling marks and thus lower drag. A Remington 700 5R Mil-Spec chambered in 300 Winchester Magnum was used. The bullets used were a 155.5 grain Berger Fullbore Boat Tail and a 125 grain Nosler Ballistic Tip with near and far velocities measured with chronographs at 15 and 315 feet. G1 and G7 ballistic coefficients were calculated using the JBM online ballistics calculator including environmental conditions measured with a Kestrel 4500 Pocket Weather Tracker. These measurements did not support the hypothesis; in fact, the velocity losses were greater over the 300 foot chronograph separation and the ballistic coefficients were smaller after polishing the rifle bore. This suggests that polishing the rifle bore actually increased resulting aerodynamic drag on the bullets.

Introduction

The purpose of this project was to determine the differences in the aerodynamic drag of a bullet before and after polishing the bore of a rifle. The aerodynamic drag is represented by the ballistic coefficients. Ballistic coefficients can be defined as the measure of a projectile's ability to overcome air resistance. Ballistic coefficients have an inverse relationship to deceleration. For example, a high number for the ballistic coefficient would indicate a low number for velocity loss.

Ballistic coefficients are commonly reported with reference to both the G1 and G7 standard drag curves. The physical difference of the G1 and the G7 is that the standard projectile of the G1 has a short nose, flat base, and bears more resemblance to an old unjacketed lead black powder cartridge rifle bullet than to a modern long range rifle bullet. (Litz 2009) In contrast, the G7 standard projectile has a long boat tail and its pointed nose bears a much stronger resemblance to a modern long range bullet than the G1 standard projectile. (Litz 2009)

Higher ballistic coefficient represents lower aerodynamic drag and implies lower vertical drop and less wind drift, as well as higher retained velocity and higher energy downrange. Ballistic coefficients vary depending on the make and model of the bullet, and also have some dependence on the rifle bore from which they are fired. In this analysis, we compute ballistic coefficients for both G1 and G7 drag models. The ballistic coefficient of a modern long range bullet that is referenced to the G7 standard is near constant for all velocities. In other words, a trajectory calculated with a G7 ballistic coefficient does not suffer from the same velocity dependence inaccuracies as calculations that are made with a G1 ballistic coefficient. (Litz 2009) A very obvious difference between G1 ballistic coefficients and G7 ballistic coefficients is that the numeric value of the G7 ballistic coefficient is lower than the numeric value of the G1 ballistic coefficient. For example, if a bullet has a G1 ballistic coefficient of .550, the G7 ballistic coefficient will be close to .282 for the same bullet. Even though the G7 ballistic coefficient is a more accurate representation of the bullet at all speeds, the numeric value of the G7 ballistic coefficient is lower. Now that we have an understanding of the G1 and G7 drag models, we can move on to how the ballistic coefficient is determined.

The details of ballistic trajectories can be predicted with computer programs using all the relevant variables of near velocity, far velocity, chronograph separation, drag function, temperature, pressure, humidity, altitude, and ballistic coefficient. As with all prediction programs, the accuracy of the outputs depends on the accuracy of the inputs. It is necessary to examine the real meaning and implications of using a ballistic coefficient to characterize the bullet's ability to maintain velocity.


Figure 1: Remington 700 5R Mil-Spec in 300 Win Mag used in testing.

Method

The rifle used in this experiment was a Remington 700 5R Mil-Spec chambered in 300 Winchester Magnum, which has been used in the M24 sniper weapon system. Made of 416R Stainless Steel, the bore twist is 1-turn-in-11.25 inches and the rifling is 5 radial lands and grooves (5-R) with a right-hand twist. Because of the odd number of lands, none of the lands are 180° apart, i.e. in direct opposition. This is reputed to result in less bullet deformation, which produces a more consistent point of impact.

Initially the bore of the rifle was unpolished, but to properly conduct this experiment the bore of the rifle had to be polished to see the effects this action had on the aerodynamic drag of the bullets. After determining BCs of the 155.5 grain Berger Fullbore Boat Tail and the Nosler 125 grain Nosler Ballistic Tip in an unpolished bore, the bore was polished by David Tubb's Final Finish System (Tubb 2004). Ten bullets were fired for each of five different polishing levels, moving from coarser to finer grits at each level. After each polishing level, the bore was thoroughly cleaned. After completing the polishing process, the BCs were determined a second time for each bullet.

BCs for each condition were determined by measuring velocities for five bullet samples with a near and far chronograph, one at the 15 feet from the muzzle, and at the 315 feet, for a separation of 300 feet between the two chronographs. The atmospheric conditions (altitude (ft.), humidity (%), temperature (°F), and pressure (in Hg)) were measured by the Kestrel 4500. The Kestrel 4500 Pocket Weather Tracker is a complete portable weather station that measures environmental conditions, quickly and accurately. These condition measurements from the Kestrel 4500 were used in the JBM ballistics program (JBM 2011) along with near and far velocity to compute ballistic coefficients using both G1 and G7 drag models for each shot fired. Atmospheric conditions varied somewhat between firing sessions, but since the experiment was performed at an elevation of 6558 feet, the atmospheric pressure was close to 23.7 in Hg. Consequently, velocity losses at this altitude are significantly lower than the same bullets fired near sea level. The JBM software accounts for this when computing BC from near and far velocities.

Results

Tables 1 and 2 show the G1 and G7 ballistic coefficients of both the Nosler 125 grain ballistic tip and the Berger 155.5 grain Fullbore before and after polishing the rifle bore. Note that all the ballistic coefficients decreased after polishing the rifle bore. Polishing the bore of the rifle did not reduce the aerodynamic drag. The aerodynamic drag was increased instead of being reduced. However, polishing the bore did improve accuracy in both cases. For the 155.5 grain Fullbore, the average group size decreased from 1.6" before polishing to 1.2" after polishing for five shots at 105 yards. For the 125 grain Ballistic Tip, the 105 yard group size for five shots decreased from 2.0" before polishing to 1.5" after polishing.

155.5 Fullbore	Before Polishing		After Polishing	
	mean	uncertainty	mean	uncertainty
Near V (fps)	3062.7	13.4	3089.4	7.0
G1BC	0.4243	0.0087	0.3244	0.0140
G7BC	0.2106	0.0041	0.1608	0.0070
V loss (fps)	175.1	3.3	233.8	10.1

Table 1: Near velocity, velocity loss, and ballistic coefficients for the 155.5 grain Berger Fullbore Boat Tail bullet before and after polishing the rifle bore.

125 Ballistic Tip	Before Polishing		After Polishing	
	mean	uncertainty	mean	uncertainty
Near V (fps)	3008.2	6.5	2966.2	8.8
G1BC	0.2830	0.0036	0.2636	0.0072
G7BC	0.1414	0.0018	0.1318	0.0036
V loss (fps)	254.6	3.3	277.4	8.3

Table 2: Near velocity, velocity loss, and ballistic coefficients for the 125 grain Nosler Ballistic Tip bullet before and after polishing the rifle bore.

Discussion

We are somewhat at a loss to explain the counterintuitive result that polishing the rifle bore seems to increase the aerodynamic drag of bullets. One wonders if bullets might be somewhat analogous to golf balls. Perhaps in the same way dimples on a golf ball reduce drag by increasing the laminar rather than turbulent flow over the surface, the more pronounced rifling marks left by an unpolished rifle bore encourage laminar flow over the bullet surface. We did not expect this for supersonic projectiles. Another possibility might be that the bullets leave the polished bore with greater yaw than the unpolished bore and the greater yaw increases the drag until the bullet "goes to sleep" by the damping of the yaw. Both suggestions seem somewhat speculative and neither is completely satisfying. It would be interesting to see if this result holds in other rifle bores and for a wider variety of bullets. A future experiment shooting saboted bullets from an oversize bore so they have no rifling marks at all might also shine more light on this question. Polishing rifle bores with the Tubb system is commonly employed technique to improve rifle accuracy. The question is, how much is drag being increased in a given rifle barrel?

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