Schuemann Barrels
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PISTOL BARREL TWIST RATE:

The twist rate of a barrel is measured in inches, specifically the number of inches the bullet moves along the bore while the bullet rotates one full turn. A twist of 16 inches means that the bullet rotates once about it's axis each time it travels 16 inches along it's path. A twist of 32 inches means that the bullet rotates once about it's axis for each 32 inches of forward travel.

The twist provides rotational motion to the bullet, which inertially stabilizes the bullet by turning it into a small gyroscope. The inertial stabilization keeps the bullet pointed at the target. The faster the rotational velocity of the bullet the more stability the bullet has. But, as we will learn below, too much stability affects accuracy adversely.

Rotational velocity and twist are inversely related. As the twist number becomes smaller the rotational velocity become greater. At the same forward velocity a 16 inch twist barrel causes the bullet to rotate twice as fast as a 32 inch twist barrel does.

Physics and Aerodynamics.

When the bullet is on its way to the target, the bullet passes through air and is surrounded by a strong aerodynamic pressure field. The highest pressure is located at the nose of the bullet, and takes the form of a shock when the bullet is supersonic. The high pressure exerts a strong force on the bullet nose which is pointed back along the direction of travel and gradully reduces the bullets forward velocity. So long as the axis of the bullet is pointed exactly along its path this strong force vector passes through the bullets center of gravity and does not tend to tip the bullet. But, for various reasons the bullet axis is not always pointed along its path. The force vector then does not pass through the bullet's center of gravity and the force tends to rotate the bullet nose away from the bullet's direction of travel.

If the bullet were fired without a rotational velocity (no spin) it is easy to imagine that the bullet would then simply tumble. With sufficient rotational velocity produced by the rifling twist a more complicated motion results. In the simplest case the nose of the bullet describes a circle centered on the axis passing through the bullet's center of gravity and aligned with the direction of the path of the bullet. This circular motion is called precession and is the response of any gyroscope to a force, or more precisely a force couple, which is trying to deflect the gyroscope from its original spin axis.

Somewhat more complicated is a second circular motion superimposed on the circular motion described above. Here the nose of the bullet is describing a (usually) small, but faster circular motion as the nose is describing the slower circular motion about the path of the bullet. This additional motion is called nutation.

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Of more importance, we need to examine what happens as we go to higher and lower rotational velocity by adjusting the twist of the barrel.

If gyroscopic stability helps keep the bullet pointed at the target we might want to go to a faster twist barrel (smaller twist number, i.e. reduce the twist to 8 inches). While this would produce more gyroscopic stabilization, the bullet RPM (rotations per minute) would increase. A 115 grain bullet at a 180,000 power factor fired through an 8 inch twist barrel would be traveling at 1565 FPS (feet per second) and rotating at 140,850 RPM when it left the muzzle. Such a rotational velocity is capable of causing two problems. One is that the required centripital forces can result in a soft lead bullet or a thinly jacketed bullet changing shape (expanding diametrically) thereby producing a loss of accuracy. The other is that if the bullet's center of gravity is not on the barrel's groove axis, the bullet's center of gravity will be spiralling as it passes along the bore. This isn't a problem until the bullet reaches the muzzle. The spiral motion of the bullet's center of gravity consists of an axial velocity component (along the path of the bullet) and a small transverse velocity component (perpendicular to the path of the bullet). This transverse velocity component causes the bullet's center of gravity to leave the muzzle moving somewhat sideways to the axis of the barrel bore, and hence on a path headed to a point somewhat to the side of the intended impact point on the target. The greater the bullet's rotational velocity, the farther away from the intended target point the bullet will impact.

Since accuracy is a major concern we might want to go to a slower twist barrel (larger twist number, i.e. increase the twist to 48 inches). In this case our 115 grain bullet will only be turning 23,475 RPM and clearly would not be in danger of changing shape. The centripital forces would only be 2.8% of the centripital forces present when the bullet was turning at 140,850 RPM.

Unfortunately, such a slow rotational velocity adversely affects the gyroscopic stabilization. The gyroscopic effect is now too small to keep the nose of the bullet pointed along the path of the bullet, and the bullet tumbles.

The Contributions of Bullet Shape and Velocity

While the shape of a bullet, expecially the nose shape, can somewhat affect the minimum twist needed to stabilize the bullet, the most important single factor is the length to diameter ratio (the bullet's L/D). As the bullet becomes longer the force on the bullet nose has more "leverage" to tip the bullet. To counteract this increased leverage the rotational velocity of the bullet has to be increased to maintain stability, and the barrel therefore has to have a faster twist (smaller twist number) to produce the higher bullet rotational velocity.

There is only a small velocity dependence on the stabilization of a given bullet. Both the gyroscopic stabilization and the force on the bullet's nose, which destabilizes the bullet, are proportional to the square of the bullet's velocity. Hence, the net stabilization of the bullet is independent of the bullet's velocity.

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But, there is one minor exception to this rule. When the bullet is trans-sonic the force on the bullet increases somewhat more than the squared velocity dependence predicts, which causes a bullet to be somewhat less stable when it passes through the speed of sound. If the bullet is trans-sonic and marginally unstable, increasing (or decreasing) the velocity of the bullet will allow the bullet to stabilize.

Since, we often send our bullets downrange at just above the speed of sound, we could theoretically see bullets which come out of the muzzle above the speed of sound and stable, but go unstable as the velocity decreases downrange and the bullet velocity becomes trans-sonic.

Empirically, it has been found that the best accuracy is obtained when the bullet is minimally stabilized. Hence, it is best to use the slowest twist which will stabilize the bullet if accuracy is an important consideration. However, when approaching the twist which minimally stabilizes a given bullet weight some bullets of that weight will be stable while other bullets of the same weight will not. This results from differences in the bullet shapes, and changes in the bullet's weight distribution.