Muzzle Device Types for Firearms

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Firearm Physics: The Problem with Muzzle Energy

Firearms use the conversion of a solid propellant into expanding gas via combustion to propel a projectile out of a barrel toward a target. As the projectile leaves the barrel, gas pressure is released at the end of the barrel—known as the muzzle—and escapes in all directions. This excess energy is released in the form of sound, heat, light, and pressure. The most notable aspect is the sound of a loud percussive explosion and, depending on various factors such as the amount of powder and barrel length, a flash of light created in the form of a ball of burning gas at the muzzle. This flash of light can be nearly imperceptible, especially if the ambient light is bright such as during midday; at the other extreme, it can be a basketball-sized fireball that can temporarily ruin the night vision of the user during low light conditions. The pressure wave is not perceivable in relatively low powered firearm cartridges, but in more powerful ones the pressure wave can be felt. In very powerful firearms, the pressure wave can cause discomfort and even temporary dizziness for bystanders.

The First Practical Use of Muzzle Energy

As early as 1890, John Moses Browning had noted that the muzzle blast from his 1873 Winchester lever action rifle would push over the weeds in front of him when fired while hunting in the brush. From this observation, he proceeded to harness this energy with a plate in front of the muzzle whereby the projectile could pass through a hole in the plate and resulting gas pressure expelled at the muzzle would push the plate forward. Additionally, the plate was attached to a rod that mounted on the lever of the rifle, so that upon firing, the lever would be worked loading a new round. The use of this excess muzzle energy would automatically load a new round and allow the cycle of firing to continue.

Thus, as the energy at the end of the muzzle was recognized, various methods were developed to try to control, use, and dissipate this energy by attachment of various devices on the end of the muzzle. Four families of devices have developed over the years, and can be broken down into suppressors, linear compensators, flash suppressors, and muzzle brakes.

Devices to Control, Use, and Dissipate Muzzle Energy

Suppressors

Despite the commonly accepted wisdom that they are a relatively recent invention, suppressors are chronologically the oldest of the muzzle devices as it is generally accepted that Sir Hiram Maxim sold the first commercially available suppressor in 1902, with versions of this device existing even earlier. A suppressor is designed to reduce the sound and flash of a firearm by providing an enclosed container

where the expanding gasses expelled from the muzzle can slow and cool down. This is accomplished by having a large, sealed chamber at the end of the barrel with a hole for the bullet to exit, and several walls, known as baffles, inside of the chamber that the gas will impact on, forcing it to change direction and lose energy and velocity in the process. The chamber is also many times larger than the bore of the barrel. This large, contained volume, in combination with the baffles, gives space and time for the gas to cool down, lowering it below the point of ignition and drastically reducing sound, light, and pressure wave. Suppressors in fact, function very similarly to a car muffler. Suppressors can often lower the sound level from the point of causing hearing damage to just below that level. Despite "Hollywood" special effects indicating the suppressors are extremely quiet, the reality is that even with a suppressor hearing damage can result and the sound of a firing is still typically on a range between painful and uncomfortable. The one disadvantage of a suppressor, besides current legal restrictions in the United States, is that they are relatively large and bulky and add considerable length to the firearm.

Linear Compensators

The linear compensator was also invented prior to the turn of the century and can be found on guns as early as the Madsen series of light automatic rifles (circa late 1800s). These types of muzzle device share the features of being essentially a tube or cone attached to the end of the muzzle that helps direct the gas forward as opposed to expanding in all directions after leaving the muzzle. The tube versions are larger than the bore diameter of the firearm while cone versions expand outward from the muzzle end similar to the bell of a trumpet. The advantage of this is the gas and associated light, sound, and pressure are pushed generally forward. This reduces the user's perception of all three but does not reduce the overall signature of each in a meaningful way. These were originally referred to as "flash hiders" as the intent was to hide the flash from the user so as not to reduce their vision, most often during low light use of the firearm. Once the properties of suppressing the flash were better understood and slots were introduced, thus creating a new separate category of muzzle devices, the term "flash hider" fell out of favor for the more current linear compensator terminology. Despite their name, linear compensators do not really offer any measurable compensation as this is more a marketing term to indicate that the device throws the expanding gas signature forward in a linear direction. Several subvariants exist including having a cone within the tube, multiple linear paths that exit the end of the device and so forth. However, the end result of these devices is much the same as they generally work to push the energy forward out of the muzzle as opposed to expanding it in all directions immediately upon exit.

Flash Suppressors

The flash suppressor—sometimes known as a flash hider in the early days of its adoption—is used to reduce the flash signature not only for the user, but also to anyone else observing the shot being fired. By controlling the release rate of the expelling gas, it is possible to reduce or even eliminate the flash. This is typically done by having a number of slots in the muzzle device cut parallel to the line of the barrel. By doing this, the gas is released into the atmosphere at a controlled rate and not all at once. Flash hiders do not typically increase or decrease the sound aspect of the muzzle energy but have the advantage of requiring very little space or length to function compared to the bulk of a suppressor.

Muzzle Brakes

Muzzle brakes take a different approach by capturing some of the energy coming out of the muzzle to reduce the recoil and muzzle rise of the firearm felt by the user. Muzzle brakes typically have slots or holes that direct the gas out of the sides and top to allow the gas to vent in a certain direction, almost acting like a miniature rocket engine to push the muzzle end of the firearm down. These slots or holes can be designed to offer a surface perpendicular to the muzzle so that gas impacts that surface and the resultant energy pushes the firearm forward to counteract the recoil. This reduction in recoil through the use of the excess energy allows the person firing to exert control more easily as the net force of the firearm pushing back against them or the muzzle rising is reduced, and therefore less work is necessary to re-aim the firearm after a shot. The downside is that the impact and venting of this gas often causes a large flash and sound energy to be redirected to the sides. The flash can be the same or, depending on the design, even larger than that of a gun with no muzzle device at all. The sound being directed to the sides can be distracting and even painful to persons located to the sides of the firearm.

Investigating a Firearms Mishap

When investigating a firearms incident involving muzzle devices, three areas will be considered. First is to see if the device functioned properly or is matched to the firearm. The equipment needs to be assessed. Second, what was the operating environment? Was there possibly a foreign object in the muzzle device or barrel? Were the operating conditions within the bounds of the equipment? Third, how was the user operating the firearm and how did they install the muzzle device?

This three-pronged approach of assessing the equipment, the environment and the operator, is how Solution Engineering investigates every incident no matter what part of a firearm may be involved.

Conclusion

Multiple categories of muzzle devices have been developed either to change the signature of the gas and energy being expelled from the muzzle of a firearm or to take advantage of that energy to improve the user experience. As with all engineering choices, these various strategies inevitably have advantages and disadvantages depending on the particular features chosen in the design for the desired resulting performance.