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Barrel Steel

When we entered the barrel manufacturing business in 1992 we did not know which steel would be the best choice for pistol barrels. But, finding that virtually all pistol barrels were manufactured from Type 416 Stainless Steel made it easy to decide to use 416 stainless in our barrels too. Since then we have learned that 416 stainless is not the best steel for pistol barrels, especially given the way we use pistol barrels in IPSC shooting. But 416 does have many properties which facilitate the successful manufacture of pistol barrels. Hence the manufacturers of pistol barrels prefer using Type 416 Stainless Steel.

There are a number of problems with 416 Stainless Steel

Problem number 1:
416 Stainless is not very "stainless".

The term "stainless steel" conjures up an image of a steel which is impervious to attack by water and common chemicals. Unfortunately, Type 416 Stainless Steel easily rusts and corrodes, though not as readily as the carbon steels do. This 416 characteristic is discussed extensively in the section of this web site on the cleaning of pistol barrels.

Problem Number 2:
416 Stainless is not a good heat conductor.

Type 416 Stainless is an alloy steel, and therefore has less thermal conductivity than less exotic steels. Its thermal conductivity is roughly half of the thermal conductivity of basic steel. This results in some general problems and one specific problem.

The general problems result from the hot propellant gasses in contact with the barrel bore. The propellants we use have a flame temperture of about 4500 degrees Fahrenheit. Because of adiabatic compression the temperature of the propellant gasses can increase to temperatures much higher than 4500 degrees Fahrenheit. This hot gas sweeps down the bore when a round is fired. The hot gas transfers heat into the surface of the bore. After each round is fired the heat which flowed into the bore surface is gradually conducted away by the barrel steel. Because the 416 steel has less thermal conductivity the heat flows away more slowly and if numerous rounds are fired in quick succession the surface temperature of the bore can become higher than a basic steel bore surface would.

While we don't have quantitative measurements of peak bore temperature we do know that some returned barrels have a brownish purple color on the bore surface which indicates bore surface temperatures reached a minimum of 1300 degrees Fahrenheit for extended periods of time. Such temperatures would anneal the 416 steel, thereby permanently softening the steel surface. This softened steel surface would be more easily scratched and worn by the subsequent passage of bore brushes and bullets, as discussed in the barrel cleaning section of this web site.

In addition to softening the barrel bore there is also the problem of increased erosion of the barrel bore by the hot gasses and propellant particles. At higher temperatures the steel bore surface is eroded away more quickly than it is at lower temperatures. This is most serious near the chamber where the propellant gas pressure and temperature are the highest. The lifetime of most barrels is determined by the amount of barrel bore erosion near the chamber. After the barrel bore diameter just in front of the chamber increases by 0.001 inch, or, at most 0.002 inch, the barrel will suddenly become noticably inaccurate and the barrel will have to be replaced.

The specific problem related to relatively poor thermal conductivity is also related to 416 Stainless Steel chemistry and will be discussed in the next section.

***Problem number 3:
416 is a "free machining" steel.***

Type 416 Stainless Steel is essentially Type 410 steel with some sulphur added. The sulphur content of commercial 416 stainless steel is very low, typically only a few tenths of one percent. The 416 stainless we use to manufacture our pistol barrels is specially manufactured for us and only has about 1/4 of the sulphur present in commercial 416 stainless.

The sulphur in 416 Stainless is present in the form of physically weak low melting point alloys. These alloys are formed between sulphur and some of the existing ingredients of the steel.

The reason for including sulphur in 416 stainless is to deliberately create points of weakness in the steel because this enhances machinability (chip breakage). Unfortunately, these locations of weakness are not located at random points throughout the steel. They are concentrated along lines (called stringers) which are parallel to the axis of the barrel.

Our 416 Stainless bar is specifically produced to our requirements and is called Type 416R Stainless, where the R designates Rifle Barrel Quality. The sulphur content in the barrels we use to make pistol barrels is 0.13%, which is below the minimum sulphur specification for 416 stainless. Our steel is specifically tested to ensure the desired physical characteristics are present. The steel undergoes dye penetrant, ultrasonic, and electromagnetic eddy current testing before leaving the mill to be sure there are no voids or other mechanical problems in our steel bars. This ensures our barrels are made from the very best 416 Stainless steel obtainable.

Later we will discuss some mechanical consequences of the presence of the sulphur compound stringers. But, in the following paragraphs we will discuss the thermal consequence resulting from the presence of the stringers of sulphur compounds in the barrel steel.

We discussed above the normal process of erosion of the bore by hot gasses and particles. In fact, the situation is worse with Type 416 Stainless Steel than with other steels not containing free machining additives. Some of the stringers of the low melting point sulphur compounds are exposed on the surface of the bore. The hot propellant gasses will possibly melt these stringers. The melted sulphur compounds could then be blown away by the high velocity hot gasses leaving exposed openings in the surface of the bore. These openings theoretically could cause significantly accelerated erosion of the bore surface.

Problem number 4:
416 Stainless has poor shear strength and fatigue resistance along the axis of the sulphur compound stringers

If you think of the upper and lower barrel lugs as being "glued" onto the barrel, and you imagine that there are lines of weakness in the glue joint (the stringers), it is easy to understand why it will be relatively easy to shear off the upper and lower barrel lugs if they are exposed to too much stress or too many repeated stresses.

Excessive stresses in the upper and lower barrel lugs generally result from poor gunsmithing or shooter choices of compensators, bullets, and propellant.

In the poor gunsmithing category are poorly timed guns which experience "crashes" between the slide, barrel, and frame. This subject is covered in the Timing Test Kit section of this web site.

In the shooter choice category are the use of heavy compensators in unlimited class IPSC competition and the use of heavy bullets and fast powders in limited class IPSC competition.

The heavy compensators used in unlimited IPSC guns increase the stesses in both the upper and lower barrel lugs. When a round is fired the force of the cartridge is applied against the slide bolt face. The resulting acceleration of the slide is coupled through the upper barrel lugs to the barrel which has the compensator attached. The heavier the compensator becomes, the larger are the stresses in the upper barrel lugs required to accelerate the barrel/compensator aft with the slide. These larger stresses increase the probability of the upper barrel lugs shearing off.

After the barrel unlocks from the slide, the lower barrel lugs hit the frame which stops the aftward motion of the barrel and compensator. The heavier the compensator the larger the stresses created in the lower barrel lugs to stop the motion of the barrel/compensator. These larger stresses increase the probability of the lower barrel lugs shearing off.

The heavy bullets and fast powders used in limited IPSC guns result in exceedingly high and erratic peak pressures. The resulting high acceleration of the slide caused by high peak pressure creates excessive stresses in the barrel upper lugs in order to accelerate the barrel aft with the slide. The lower barrel lugs in limited IPSC guns also fail at greater rates than normal, possibly because of the very high number of total rounds fired through these guns which causes metal fatigue of the lower barrel lugs.

Problem number 5:
Because of Problems 1, 2, 3, and 4 Type 416 Stainless is not a good material for sub-gun barrels

In IPSC applications firing rates can approach the firing rates of the low firing rate sub-guns (400-500 rounds per minute). The actual average rounds per minute can also approach the average rounds per minute of sub-guns (200-300 rounds per minute). This kind of shooting can potentially push 416 Stainless beyond reasonable limits and cause high barrel temperatures that can reduce barrel lifetime. We have seen barrels that were completely worn out (the lands were completely worn away and the barrel had been converted into a smooth bore) after reportedly firing less than 1500 rounds through the barrels. Luckily, this has only happened a few times. In one case the gun owner admitted that he had "kind of gone crazy" with his new open class gun because he was so pleased with how flat it shot when he was first testing it.

Problem number 6:
416 stainless barrels tend to split open when exposed to significant overpressure.

The longitudinal tensile stress capability of 416 barrels is virtually unaffected by the presence of the sulphur compound stringers. Not so the transverse tensile strength (perpendicular to the stringers). The strength of the barrel to resist the high pressures we subject the barrels to is reduced by the presence of the sulphur compound stringers. We have never been able to find anyone who knows just how much the transverse tensile stess capability is reduced by the presence of the sulphur compounds. But, it is a sufficiently important factor such that when a barrel is over pressurized it splits open along the sulphur compound stringers (along the length of the barrel), thereby venting the barrel prematurely, rather than blowing up like a bomb.

Therefore this "problem" with 416 stainless is really a blessing in disguise because many injuries have likely been prevented when 416 barrels split open before pressures got outrageously high. The barrel usually splits open forward of the magazine well and inside the slide.

This reduces the severity of the damage to the shooter, as the cartridge case didn't have a chance to be extruded out of the chamber and vent the propellant gasses down into the magwell likely setting off other rounds and doing many kinds of serious damage to the shooter's hand.

The premature splitting of 416 barrels also reduces the chance that bystanders will be injured, as the violence of the venting gasses and any resulting shrapnel will likely be contained within the slide.