LEAD FREE FRANGIBLE IRON BULLETS

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ABSTRACT

The invention relates to sintered iron bullets having increased frangibility (or which can be easily fragmented) and to the materials and processes for the manufacture of such bullets. The bullets of the present invention are typically made from iron powder (including powdered iron from scrap iron) which are pressed to form a briquette and then sintered under conditions so as to obtain bullets with the desired level of frangibility. In the preferred embodiment of the invention, the bullets are resin or plastic impregnated and then coated to facilitate lubricity and prevent corrosion.
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<th>Bullets - Sintered Testing</th>
<th>6/11/2015</th>
<th>1,400 Deg. Sinter (F-1) No Hydrogen 5.5 BKS</th>
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<tr>
<td></td>
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FIG - 7
LEAD FREE FRANGIBLE IRON BULLETS

FIELD OF THE INVENTION

[0001] The present invention relates to a frangible firearm projectile.

BACKGROUND OF THE INVENTION

[0002] Traditionally, bullets for small arms ammunition have been manufactured from lead and lead alloys. The major advantages of lead as a bullet material are its relatively low cost, high density and high ductility. The high density of lead has been important to bullet design because the energy generated by the weight of a bullet has generally been thought to be important to the proper functioning of modern semi-automatic and automatic weapons, the in-flight stability of the round, and the terminal effects of the bullet.

[0003] The highly toxic nature of lead, however, and its propensity to fume and generate airborne particulate, place the shooter at an extreme health risk. The more a firing range is used, the more lead residue builds up, and the greater the ensuing lead fume and lead dust pollution (particularly for indoor ranges). Moreover, the lead bullet residue left in the earthen berm of outdoor ranges can leach into the soil and contaminate water tables. In order for indoor ranges to operate safely, they require extensive and expensive air filtration systems, and both indoor and outdoor ranges require constant de-leading. These cleanup operations are time consuming, costly and repetitive. Accordingly there is a great need for lead free bullets.

[0004] Additionally, personnel at range operations are concerned with the ricochet potential and the likelihood of causing “back-splatter” of the training ammunition. Back splatter is a descriptive term for bullet debris that bounces back in the direction of the shooter after a bullet impacts on a hard surface, such as steel targets or backstops. Ricochets present a significant hazard to individual equipment and structures in and around live firing ranges. A ricochet can be caused by a clanking impact by a bullet on almost any medium. Back splatter presents a significant danger to shooters, training personnel standing on or around the firing line and observers. When a bullet strikes a hard surface at or near right angles, the bullet will either break apart or deform. There is still energy in the bullet mass however, and that mass and its energy must go somewhere. Since the target material or backstop is impermeable, the mass bounces back in the direction of the shooter.

[0005] It is believed that a key way to minimizing the risk of both ricochet and back splatter is to maximize the frangibility of the bullet. By designing the bullet to fracture into small pieces, one reduces the mass of each fragment, in turn reducing the overall destructive energy remaining in the fragments.

[0006] Several prior art patents disclose materials and methods for making non-toxic or frangible bullets or projectiles, U.S. Pat. No. 5,442,989 to Anderson discloses projectiles wherein the casing is frangible and made out of molded stainless steel powder or a stainless steel/pure iron powder mix with up to 2% by weight of graphite. The casing encloses a penetrator rod made of a hard material such as tungsten or tungsten carbide.

[0007] U.S. Pat. No. 4,165,692 to Dufort discloses a projectile with a brittle sintered metal casing having a hollow interior chamber defined by a tapering helix with sharp edge stress risers which provide fault lines and cause the projectile to break up into fragments upon impact against a hard surface. The casing is made of pressed iron powder which is then sintered.

[0008] U.S. Pat. No. 5,399,187 to Mravic et al discloses a lead free bullet which is comprised of sintered composite having one or more high density powders selected from tungsten, tungsten carbide, ferrotungsten, etc. and a lower density constituent selected from tin, zinc, iron, copper or a plastic matrix material. These composite powders are pressed and sintered.

[0009] U.S. Pat. No. 5,078,054 to Sankaranarayanan et al, discloses a frangible projectile comprising a body formed from iron powder with 2 to 5% by weight of graphite, or iron with 3 to 7% by weight of Al,sub 2 sub 3. The powders are compacted by cold pressing in a die or isostatic pressing, and then sintered.

[0010] U.S. Pat. No. 6,074,454 to Abrams et al., discloses lead free frangible bullets and process for making same out of copper and copper alloy powders.

SUMMARY OF THE INVENTION

[0011] The invention relates to bullet projectiles (see FIG. 1 below) having increased frangibility (or which can be easily fragmented) and to powder materials and processes for the manufacture of such bullets. The projectiles of the present invention are made from powdered iron, at least 95%, or with other elements being a lubricant and other iron sintering materials. The projectiles are then resin or plastic impregnated (see below). Additionally, the invention provides a simple low cost process to make bullets that are amenable to mass production via automation.

BRIEF DESCRIPTION OF THE DRAWINGS

[0012] FIG. 1 (A) is a side view of a typical bullet projectile made in accordance with the technique of the present invention;

[0013] FIG. 1 (B) is a front view of the bullet of FIG. 1 (A) of the present invention;

[0014] FIG. 2 is a view of a fragmented bullet after firing in a test facility;

[0015] FIG. 3 is a view of particles collected from an fragmented projectile made in accordance with the teachings of the present invention;

[0016] FIG. 4 is a view of the projectile testing equipment;

[0017] FIG. 5 is a detailed view showing a bullet in the testing apparatus;

[0018] FIG. 6 (A-6C) shows projectiles tested for consistency in the testing apparatus of FIG. 4 prior to loading into a live round; and

[0019] FIG. 7 is a table showing bullet test data.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0020] The embodiments described in this section are intended as examples only and are not to be construed as limiting. In fact there are hundreds of bullet designs that could be made using the materials and the processes described in this disclosure. Moreover, the present disclosure is not intended as a treatise on bullet manufacturing. Readers are referred to appropriate available texts in the field and any additional and detailed information on bullet manufacture and other aspects of practicing the invention.
Iron is the preferred material of choice for making projectiles of this invention, it is non toxic and has a reasonably high density (6.2 grams/cc minimum). Iron powder technologies typically do not allow for frangibility, but this unique combination of material composition, density and sintering techniques allow for a frangible bullet 10 out of an iron composition. With the addition of outer coatings such as copper plating or phosphates (such as copper, manganese phosphate or zinc coatings) or other plating materials the projectile will have a lubricious coating to not prematurely wear the barrel of a gun. The preferred process to make the bullet of this invention involves first blending the iron powder with a suitable briquetting lubricant, typically composed of Zinc Stearate in amounts of generally from about 0.3% to about 1.0%, and preferably from about 0.6% to about 0.8% wt % lubricant. Many other briquetting lubricants may also be used such as Acrarwax, Kenolube, stearic acid and die wall lubrication systems. Then cold compacting of the powder in a die is facilitated at a pressure that produces a part having a green strength of sufficient interconnected porosity to allow for the lubricant vapor to escape during subsequent sintering treatment. Such cold processing pressures are generally from about 20 tons to about 50 tons and typically from about 25 tons to about 35 tons. The parts are molded using standard powder metal techniques. The material was pressed at room temperature at approximately 3 tons of force in a 5 ton Morotech compacting press. The iron powder is pressed into a density of 6.2 g/cc minimum of generally from about 6.4 grams/cc to about 7.0 grams/cc, and preferably from about 6.6 grams/cc to about 6.8 grams/cc of said powder.

The bullets 10 are then sintered by heating in a protective or controlled atmosphere to prevent oxidation. The sintering can be done in a standard belt furnace consisting of several "zones". The sintering process consists of loading parts onto a furnace that is divided into heat zones described in order as the Pre-Heat Zone, the Hot Zones and the Cooling Zones. The parts are loaded onto a continuous belt at a fairly rapid belt speed. The atmosphere inside the furnace is controlled to keep moisture and oxygen out of the zones. The temperature of the parts rises to approximately 1400°F, going into and through the Pre-Heat Zone. The parts run through the Hot Zones set to a sintering temperature of generally from about 1000 to 1800°F, typically 1400-1600 degrees F and preferably 1400 to 1500°F, the exact temperature and time depends on material and the intended frangibility requirements. The parts exit the Hot Zones and enter into the Cooling Zone in an inert (nitrogen) atmosphere. The parts then exit the furnace cool enough to handle.

The final stage of manufacture for the projectiles is impregnation and coating. In order to properly apply the above mentioned coating to the bullets the projectiles are resin impregnated or "polymerized" as follows. Projectiles are placed into a tank of impregnating material (Loctite PM5120) at room temperature. The tank is sealed and a vacuum is drawn for 30 seconds. Then the tank is left at vacuum for an additional 30 seconds of soak time. During this time the air is removed from inside the pores of the part and replaced with the impregnating material. After exposure to the air, the impregnating material hardens (an anaerobic material) and forms a solid mass within the projectile. This inhibits subsequent cleaning fluids and coating materials from becoming trapped inside the projectile pores. The projectiles then go through a rinse of tri-sodium phosphate to clean the part surfaces.

The projectiles are then copper coated or phosphate coated or otherwise plated to improve the lubricity, for corrosion protection and/or for appearance of the projectile. Standard manufacturing techniques can be used for all these coatings at this point in the process. This is followed with a coating or plating using either copper in accordance with ASTM B734-97 Class 5 or coated with manganese phosphate or zinc phosphate with oil using MIL-DTL-16232 F Class Z Type 2 or plated with any other typical plating materials. This is done for appearance, corrosion protection and lubricity (so the bullet does not prematurely wear the barrel of the gun).

Lower density and lower sintering temperature increase the frangibility while higher density and higher sintering temperature decrease frangibility. The bullets must have sufficient integrity to withstand the firing operation without breaking up in the barrel of the gun or in flight up to the target, the bullet must also have sufficient frangibility so that it breaks up into small pieces upon impact against a hard surface.

It must be noted that different users of ammunition may prefer different degrees of frangibility. Some prefer to have as complete a breakup into as small of particles as possible to eliminate any ricochet or back-splatter and minimize penetration of the steel backstop. Some prefer the breakup into small pieces rather than powder to minimize airborne particles, and at the same time also minimize the ricochet potential.

The technology disclosed in this invention can accommodate most, if not all, of the frangibility requirements. As mentioned above, one way to control frangibility is through control of density, sintering temperature and sintering time.

EXAMPLES

The following examples illustrate embodiments of the process and the lead-free frangible bullets of the present invention.

The material selection in example 1 for the bullet projectile matches the Chemical elements of Metal Powders Industries Federation (MPIF) material grade FY-4500-20V per MPIF standard 35. The projectile does not meet the physical properties of this MPIF grade due to the temperature used for sintering. This material was selected due to its low cost and suitable compressibility in molding. However, the actual material composition for making the bullets would not be restricted to this grade. Any iron based material grade in the standard that is molded to the same density and sintered as described here would give virtually the same flight and fragmentation results. It is primarily the added cost of other alloying elements such as copper in the MPIF FC grades and nickel in the MPIF FN grades and other combinations of alloying elements in the FD, FLN, etc grades that determined the material selected for our use. Also, other alloying elements would not be desirable as cast off metals in the soil.

Example 1

One grade of iron powder produced by Hoeeganaes Corporation was blended with die lubricant, assigned these numbers:

1) 96.35% iron with 2.90% Fe 3 P 16% and 0.75% zinc stearate (lubricant)
2) The base iron material is trademarked under Hoeeganaes Corporation's name Anchorsteel 1000C
About a 90 grain sample of the powder blend was pressed (molded) in a die to make the 9 mm projectiles. Projectile size was approximately 9 mm (0.354 inches) diameter x 13.5 mm (0.53 inches) long. The bullets were sintered in a belt furnace in a 100% nitrogen atmosphere. Density of bullets was determined using the water immersion technique. Bullets were then resin impregnated and coated with zinc phosphate per MIL-DTL-16232 G Class Z Type 2. Other normal plating processes can be used at this point to alter the appearance/color of the bullet. This is followed with a coating or plating using either copper in accordance with ASTM B734-97 Class 5 or coated with manganese phosphate or zinc phosphate with oil using MIL-DTL-16232 G Class Z Type 2 or plated with any other typical plating materials. This is done for appearance, corrosion protection and lubricity (so the bullet does not prematurely wear the barrel of the gun).

The sintered projectiles were assembled into rounds as follows: New Remington cases were purchased. These cases were sized, case mouth expanded, and primed with Winchester Small Pistol primers in an RCBS Rock Chucker press with a RCBS Pappyback II Progressive loader attachment. The powder was loaded into the cases with a Redding Match Grade 3FR Powder Measure with Universal Metering Chamber. The measure was set to throw a 5.3 grain charge of WW-231 smokeless powder, using a RCBS Chargemaster 1500 electronic scale. The bullets were seated on a Redding Big Boss II press. The 9 mm dies that were used throughout were manufactured by Lee Precision, Inc. into 9 mm Luger primed cartridge cases using sufficient commercial smokeless propellant to produce velocities and pressures within the range normally encountered for 9 mm Luger ammunition, and separated into bullet weights and type of bullet lubricant. The completed rounds were test fired. The test setup and pistols used were all commercially available items, 9 mm pistols were used. The absence of the breakup in the barrel or in flight was determined by placing paper witness cards along the flight of the bullet. Frangibility was determined by allowing the bullets to impact a thick (5/8 inch) steel backstop placed perpendicular to the bullets line of flight at the rear end of a wooden collection box. The bullets entered the box through a hole covered with a paper witness card. The fragments generated from the impact of the bullets against the steel plate were collected. The fragments were screened over a Tyler 14 mesh screen 14. The components collected over the screen were labeled fragments, and the materials passing through the screen was labeled powder. Each was weighed to detail frangibility.

A test round with the resin impregnation and zinc phosphate fragmented as follows:

Total weight prior to screening=5.40 grams (see FIG. 2 below)
Screened powder (or small particles) 12 passing through the 14 mesh screen 14=1.40 grams (26%)
Fragments not passing through the 14 mesh screen=3.90 grams (72%) (see FIG. 3 below)
The balance of 0.10 (2%) grams was attributed to dust lost during screening.

The largest fragment size was no greater than 0.32x 0.21x0.38 inches and weighed no more than 0.69 grams (13%).

A second test of the bullets from example 1 was completed using 10 rounds and the combined weights were recorded.

Total 10 round weight prior to screening=54.36 grams
Screen powder (or small particles) passing through the 14 mesh screen=17.35 grams (32%)
Fragments not passing through the 14 mesh screen=37.01 grams (68%)
The largest fragment size was approximately 0.21x 0.22x0.23 inches and weighed no more than 0.65 grams (12% of 5.436 grams).

Example 2

Additional test firing of bullets made to the same material composition and loading techniques as pre example 1 were conducted. Except in this case the projectiles were copper plated instead of the zinc phosphate coating.

A single test round with the copper plating fragmented as follows:
Total weight prior to screening=5.54 grams
Screen powder (or small particles) passing through the 14 mesh screen=1.64 grams (30%)
Fragments not passing through the 14 mesh screen=3.90 grams (70%)
The largest fragment size was approximately 0.19x 0.18x0.16 inches and weighed no more than 0.55 grams (10%).

Example 3

Additional test firing of bullets made to the same material composition and loading techniques as per example 1 were conducted. Except in this case the projectiles were molded to a longer length of 15 mm (0.59 inches) and were a slightly higher in weight as noted below. Additionally the parts were plated using a standard zinc plating process to 0.0025 inch plating thickness.

A single test round with the zinc plating fragmented as follows:
Total weight prior to screening=5.67 grams
Screened powder (or small particles) passing through the 14 mesh screen=4.18 grams (74%)
Fragments not passing through the 14 mesh screen=1.48 grams (26%)
The largest fragment size was approximately 0.25x 0.20x0.18 inches and weighed no more than 0.28 grams (5%).

A second test of the bullets from example 3 was completed using 10 rounds and the combined weights were recorded.

Total 10 round weight prior to screening=51.95 grams
Screened powder (or small particles) passing through the 14 mesh screen=31.84 grams (61%)
Fragments not passing through the 14 mesh screen=20.05 grams (39%)
The largest fragment size was approximately 0.28x 0.28x0.18 inches and weighed no more than 0.48 grams (10% of 5.195 grams).

Frangibility will be “scored” by determining the percentage weight of the largest fragment against the bullets total weight. In the above cases it was 13%, 12% and 10%.

Additional testing was completed on the projectiles prior to assembly into a completed round. Made by Piller Corp in The City of Industry, Calif. It is a hydraulic laboratory press generally shows at 16 for load testing parts. It has been retro-
fitted with a Dillon FI-127 programmable force indicator (shown in the upper right) that reads the force applied to the ram (shown in the lower left) in pounds of force. One of the parts is shown loaded between the ram 20 and upper stop 22 in FIG. 5 and the resulting effect is shown in FIGS. 6A-6C, showing various tested projectiles 24b, 24c, and 24e.

[0065] This testing process consisted of loading the projectile into a PHI load tester (see FIG. 4 below) and applying a 2500 pound load (see FIG. 5). The projectiles were measured for length prior to load testing and again after being tested at the 2500 pound load. This change in length testing will be checked over a range of projectile weights, densities and sintering temperatures to give us a baseline for future production and will help to insure consistency of the frangibility at the different parameters. A photo of load tested projectiles 24a, 24b, 24c, and a typical test report are shown below (FIGS. 6A-6C & 7).

[0066] Higher densities allow heavier bullets to be produced without changing overall dimensions; in fact it is possible to produce 100 grain bullets which compares to 80-93 grain bullets, these bullets more closely resemble the firing characteristics of the conventional lead bullets now used in the field. However, frangibility is greatly reduced.

[0067] None of the tested bullets broke up in the gun barrel or flight indicating good integrity. The data shown confirms that the bullets made from the above iron powders had good frangibility. All the bullets did very little damage to the steel backstop. The type of coating did not have any significant impact on performance or frangibility.

Example 4

[0068] An Iron material is selected for making a sintered bullet projectile. It is selected to be particular and non toxic and has density ranges of 6.2 to 7.0 grams/cc. The particle size prior to molding ranges from 460 mesh US standard sieve to +325. The iron powder is blended with a suitable briquetting lubricant, composed of Zinc Stearate (in amounts of generally from about 0.3% to about 1.0%, and preferably from about 0.6% to about 0.8% wt % lubricant). Other briquetting lubricants may also be used such as Acrinax, Kenolube, stearic acid or die wall lubrication systems. These may also be used and found suitable. The resultant mixture is cold compacted in a die at a pressure of about 30 tons per square inch. That produces a part having a green strength of sufficient interconnectivity for the lubricant vapor to escape during subsequent sintering treatment. Cold processing pressures of about 20 tsi to about 50 tsi, typically from about 25 tsi to about 40 tsi and preferably from about 25 tsi to about 35 tsi are used and found suitable.

[0069] The green pressed projectile is placed in a continuous belt sintering oven with a 100% nitrogen inert atmosphere. The projectiles on the conveyor are run through a first temperature stage for burning off the lubricant at a temperature of about 1000° F. to 1400° F. and for a time period of about 13 minutes. Then the conveyor transports projectiles to a sintering chamber (hot zone) where the projectiles are sintered at temperatures of about 1400° F. to 1500° F. for about 17 minutes. The projectiles continue into a cooling zone before exiting the furnace.

What is claimed:

1. A frangible bullet comprising at least 95% by weight iron and manufactured by pressing an iron containing powder in a die to form a briquette and subsequently sintering said pressed powder compact, wherein said sintering:
   a. includes the addition of lubricants to aid in the briquetting process said lubricants comprising a mixture of range of generally from about 0.3% to about 1.0%, wt % lubricant, typically Zinc Stearate;
   b. includes a lubrous coating and the coating ranges generally less than 1% by weight, often no significant weight increase with the phosphate coating; and
   c. controls the density of said briquette in a range of generally from about 6.2 grams/cc to about 7.0 grams/cc;
   Through control of sintering temperature, or sintering time, or any combination of the above in a range of generally from about 1000° F. to about 1800° F., so as to produce a bullet capable of fragmenting upon impact with a steel target or other similar hard surface.

2. The bullet of claim 1 wherein said lubricants are from about 0.6 to 0.8% by wt lubricant the briquette has a density of 6.6 to about 6.8 grams/cc.

3. The bullet of claim 1 wherein the bullet is sintered at a temperature of from about 1400° F. to about 1500° F.

4. The bullet of claim 1 wherein the final composition is substantially lead-free.

5. The bullet of claim 1 wherein said bullet is comprised substantially of sintered of iron powder.

6. The bullet of claim 1 wherein resin or plastic materials of from about 0.02 grams to about 0.05 grams is impregnated into the briquette to aid in the coating processes.

7. The bullet of claim 1, further comprising a phosphate coating to enhance lubricity.

8. The bullet in claim 1, further comprising a copper plating coating to enhance lubricity.

9. The bullet of claim 1 where in the bullet is plated with coating phosphate, copper and alloys and mixtures thereof.

10. The bullet of claim 9 further comprising loading of the bullet into a shell casing with propellant for producing a fireable cartridge.

11. The bullet of claim 9, wherein the briquette occurs with an additive that acts as a briquetting agent lubricant.

12. The bullet of claim 9, wherein the coating is effective for keeping the bullet lubricated for firing down the barrel of a gun.

13. The bullet of claim 1 wherein the briquetting and sintering controls:
   a. The density of said pressed powder compact to be in the range of 6.2-7.0 grams/cc; and
   b. The frangibility of the pressed powder, such that it does not break up in the barrel of a gun.

14. A method of making a frangible bullet which comprises pressing a powder containing at least 95 percent by weight iron, or iron alloy, or iron alloy powder, in a die to form a pressed powder compact and subsequently sintering said pressed powder compact, wherein briquetting and sintering forms a projectile which includes:
   a. Frangibility as measured from the largest size of fragment of generally from about 1.1% to about 15% of said powder; and
   b. Density of generally from about 6.2 grams/cc to about 7.0 grams/cc.

15. A method of claim 14 wherein the pressing of the powder is performed at a pressure ranging from 20 to 50 psi.

16. A method of claim 14 wherein the sintering is performed in a protective atmosphere at a temperature ranging from 1200 degrees F. to 2100 degrees F. for a length of time from about 10 minutes to about 4 hours.
17. The method of claim 14 wherein the bullet has a largest size of fragmentation of from about 10 to 13%.

18. The method of claim 14 wherein the bullet has a largest size of fragmentation of less than about 10%.

19. The method of claim 14 wherein the density of the bullet is from about 6.6 grams/cc to about 6.8 grams/cc of said powder.

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