Chapter Eight Metal Jackets

For many years excellent work was done with a simple piece of paper that was wrapped around a, usually, pure lead bullet. Game of all types and sizes was successfully taken using the paper patched bullet. Targets were shot at ranges exceeding 1,000 yards. Militaries of all countries defended their countries and sometimes made war using the paper patched bullet.

But technology never rests. New firearms and automatic weapons were not well served by the paper patched bullet. Velocities began to rapidly increase with the use of semi-smokeless and later smokeless powder. With the improvements in gunpowder the bore size of the projectile began to be reduced. Large heavy bullets were no longer necessary to achieve the desired killing power. Smaller cartridges could deliver a lethal blow at extended ranges. The day of the "needle blower" was nearly at hand.

The paper patched bullet was not suitable for the higher pressures and higher velocity that the new primers, cartridge cases, and smokeless power could produce. It was time for a change.

A metal jacket was needed that would take the higher rotational velocity generated by the faster twist rates in the new guns. A jacket that wouldn't foul the barrel and that could be produced rapidly and in large quantity. Many ideas were tried and rejected. Finally, after many false starts, the bullet jacket that we use today was developed. This jacket is made by cutting out a circular disk or blank from a strip of metal. The blank is then drawn into a short, large diameter cup and the cup is drawn into a bullet jacket. Usually several draws or redraws are needed along with a trimming operation to make the jacket. Different metals react differently to the process of what is called deep drawing. So let's look and the metals that have and are being used.

Bullet Jacket Material

The wire patched or wire wrapped bullet is one interesting failure. This bullet had a lead core that had a fine copper wire wrapped tightly around it. The lead core was cast in a bullet shape that had thread like grooves around the body of the bullet. The wire was waxed, cotton covered, copper wire or sometimes iron wire, often called bell wire, and was tightly machine wound around the bullet and crimped into place. A gas check usually covered the bullet's base. The bullet was designed by M.C. Lisle who called it the Lisle Wire Patched Bullet. An attempt to produce these bullets failed and the bullet was then made by the National Projectile Works in Ontario, California in about 1899. Later, the National Cartridge Company in Napa, California produced these bullets. The wire patched bullet or wire patch bullet was said to reduce barrel wear compared to the new "metal case" bullets. A wide range of calibers were made ranging from .30 caliber up to .458 caliber and there is some evidence that bullets as small as .224 have been wire patched. In about 1940 Hensley & Gibbs, the noted bullet mould makers, produced a few moulds designed to cast a wire patched bullet. A coil of small copper wire would be wound and placed in the mould. Then the lead was poured in and a cast, wire patched bullet was produced.

The idea was interesting but in use the rifling would cut through the wire so that strands of wire would be hanging off of the bullet when it left the barrel. Accuracy suffered but the bullets were said to be quite musical.

Cupro-nickel was a material that saw quite a bit of use for a short time. As the name suggests it is an alloy of copper and nickel. The percentage of nickel can run from as low as 5% and to as much as 30%. Cupro-nickel had some desirable qualities but not many. At one time it was felt to be less "poisonous" to a wound than other jacket materials and so was favored by the military. Remembering that the Hague Convention of 1899 forbade the use of expanding bullets and the Hague Convention of 1907 attempted to limit unnecessary suffering in war, the use of a jacket alloy that was thought to prevent addition injury makes some sense.

Cupro-nickel alloys can be drawn into a bullet jacket but it is more difficult to draw than copper or steel. Jackets made with this alloy fouled the barrel excessively, leaving lumps and streaks of the jacket material down the barrel. The fouling was very difficult to remove. Cupronickel jackets look like steel jackets but a simple magnet test will tell if the jacket is steel or not. However some steel jacketed bullets also had a cupro-nickel coating so the magnet test is not always definitive.

Bullets made with cupro-nickel jackets were suspected of causing a number of rifles to blow up. The thinking was that the jacket material would bond to the cartridge case; on firing the case neck would be torn off, and a blown up barrel and/or rifle would result. But many of the cupro-nickel jackets were coated with tin. Tin has a strong affinity for brass. It is more likely that tin coating the bullets caused the bullets to bond to the cartridge case and that was the real cause of the problem.

Eventually the cupro-nickel era came to an end and shooters worldwide breathed a sigh of relief.

Steel was used and is used today for bullet jackets. It has the advantage of being low in cost, it can be drawn into a jacket without a great deal of effort, and when made properly makes a good hunting bullet. Steel jackets have found plenty of use in military bullets. But steel jackets do rust, which is not desirable, so they are usually plated or clad with gilding metal or nickel. At one time steel jackets were coated with cupro-nickel. Steel jacketed bullets are common in Europe where they are used without any problems. Steel jacketed bullets are said to cause more barrel wear but tests don't bear this out. Barrel wear with steel jacketed bullets seems to be about the same as with other materials.

Perhaps this belief came about because of the use of reclaimed surplus military bullets that could be contaminated with grit or because some military bullets have much thicker, harder jackets than a hunting bullet would. Another possible reason is that barrel steels of the 1930 to late 1940 years were softer and would wear faster than modern barrels. There seems to be little reason not to use a well made steel jacketed bullet today but a bias against steel will not easily go away.

Aluminum and zinc have been tried for bullet jackets but generally haven't worked very well. Both can leave considerable fouling that can be hard to remove. Aluminum is usually too soft so that it doesn't hold the rifling as well as the harder jacket materials.

Zinc tends to leave a lumpy fouling that is moderately difficult to remove and zinc is somewhat brittle so that the jacket can crack and fold up on itself when spitzer bullets are made.

Copper has been used for jackets for many, many years. It has many advantages such as reasonable cost, it can be easily drawn into a jacket, it doesn't corrode under most conditions, it won't bond to the cartridge case, it is readily available, and it performs well in both target and hunting bullets. The only problem with copper is that it can foul the barrel some. This tends to be something of a variable. The fouling can be reduced by work hardening the copper or increased by annealing it. Some all copper bullets foul rather badly and tend to strip the rifling but others seem to have little problem. Much depends on the condition of the barrel and to some extent the load being used. Sometimes just switching powder can reduce the fouling. But copper can be easily removed from the barrel using an ammonia based cleaner.

Copper tubing can be made into jackets and copper strip is used for drawn jackets. Copper tubing is known as UNS-C12200 or 122. Copper strip is called UNS-C11000 or 110. The best tubing to use is hard drawn, straight tubing while soft copper strip is most often used.

Copper can have a small percentage of lead added to it or the element Tellurium is often used. Both lead and Tellurium greatly improve the machineability of copper. This is of little importance in a drawn jacket but it makes life much easier if heavy walled jackets are to be machined from solid rod.

Yellow brass can be used for jackets but it isn't an especially good choice. Jackets can be made from tubing (UNS-C27000), strip (UNS-C27000), or machined from rod (UNS-C36000). The alloy UNS-C27000 is 62% to 68% copper, .10% lead, and the rest zinc. It may have a trace of iron. Alloy UNS-C36000 is called Free Cutting Brass and has 60% to 63% copper, 2.5% to 3.7% lead, .35% iron, and the rest zinc. Free cutting brass, often incorrectly called yellow brass, is commonly used to make solid bullets because it machines so easily.

Both yellow brass and free cutting brass foul the barrel very badly and the fouling is difficult to remove. Both alloys are much harder than copper and that can work against it when it is used for hunting bullets. Expansion may not be all that is wanted and the brass can sometimes fracture causing the bullet to break up on impact.

Cartridge brass is sometimes used for bullet jackets and spent cartridge cases have been used as bullet jackets since the 1930's. Cartridge brass is alloy UNS-C26000. It has 68.5% to 71.5% copper content, a trace of lead and iron, and the rest is zinc. Generally bullets made with cartridge brass jackets will not foul excessively.

Hundreds of thousands of bullets have been made using fired .22LR cases for the jacket and with good results. .50 BMG bullets can be made from fired belted magnum cases, .30-06 and similar cases make into good .458 bullets, .223 cases make fine .375 bullets. The list of bullets that can be made from fired cases is pretty much limited by a person's imagination and inventiveness.

But cartridge brass is harder and more brittle than copper. The jackets made from this alloy need to be annealed or they will crack on being pointed up. The material draws easily and is readily available.

Commercial bronze is used for jackets with reasonably good success. This is alloy UNS-C22000 or 220. It is often incorrectly referred to as gilding metal but it is not and really should not be called that. Commercial bronze has 89% to 91% copper, a trace of lead and iron, and the rest is zinc. Probably the most common alloy used is 90% copper and 10% zinc. Commercial Bronze is much harder than copper when both are in the soft condition. It has a higher tensile strength than copper which can be both good or bad.

It can be used for hunting bullets but the hardness of it tends to make expansion a problem and, for the home bullet maker, it can be difficult to get it to form properly in the point forming die. On the other hand the hardness and higher strength makes it a good candidate for non-expanding bullets such as the "solids" used for big African game. It has a tendency to crack when made into bullets that have long ogives although a through anneal and a tapered jacket wall will help reduce the problem.

Gilding metal is the bullet maker's metal of choice. Gilding Metal has between 94% to 96% copper, a trace of iron and lead, and the rest is zinc. Probably the most commonly used alloy is 95% copper and 5% zinc. It is known as alloy UNS-C21000 or 210. Gilding metal probably was named that because it was used as a substitute for gold and was used to coat or gild works of art.

It is available, it can be drawn easily, doesn't corrode easily, it is a bit more expensive than pure copper but not excessively so. If annealed correctly bullets made with gilding metal jackets will expand well. And barrel fouling isn't much of a problem. All in all it is the ideal material for bullet jackets.

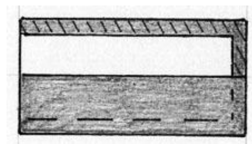
There are other materials that could and probably have been used for bullet jackets. Many of the brasses, such as Red Brass or Jewelry Bronze would work reasonably well, but the materials might be too expensive, or simply not available in a form that would be useable.

At the time that this is being written copper has skyrocketed in cost. In the past pure copper strip was less expensive than gilding metal. Now, because of the lower cost zinc in gilding metal, pure copper is somewhat more expensive. While the future is hard to predict it does seem likely that the use of steel jackets; clad or plated with copper, gilding metal, or nickel, will become much more common.

Or, perhaps we will all just go back to the paper patched bullet that worked so well for so many years.

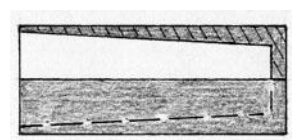
Bullet Jacket Types

Bullet jacket construction is as important as the material used for the jacket. The bullet jacket at first glance is just a simple straight tube that is closed at one end. And some jackets are just that. But others are a bit more complex.


Straight wall

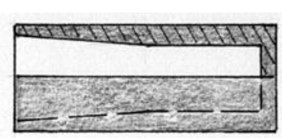
The straight walled jacket is the easiest jacket to make as it has a uniform wall thickness from one end to the other. This makes the drawing punches easier to build and the jacket performs well in most of the time. The straight walled jacket has a uniform inside diameter and only one core seating punch is needed to fit properly at any point in the jacket. This jacket works well for bullets that have blunt ogives and even for spitzers up to about an eight caliber curve. Beyond the eight caliber curve, or 8S ogive, there can be problems with the jacket folding and buckling under the forming pressure in the point form die and the jacket can crack or fold up on itself as the bullet is pointed up. This becomes a greater problem if the tip diameter of the bullet must be smaller than usual as with most target bullets.

Most pistol jackets will be straight walled jackets. Usually handgun jackets will be short compared to a rifle jacket and the pistol ogives used are fairly blunt and in this case the straight walled jacket works quite well.

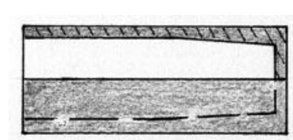

Taper wall jacket

The taper wall jacket solves the problems inherent in the straight walled jacket. This jacket can be made in several different styles.

For rifle calibers up to about .257 the jacket is usually made with a uniform taper running from the base of the jacket to the mouth of the jacket. This taper is not large being between 1/3 of a degree per side to perhaps 2 degrees per side. If the angle is too large there will be a tendency for the core to pop back out of the jacket once the core has been seated and it will make it harder to fit the seating punch to the jacket.


Straight base, tapered to mouth.

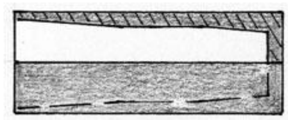
Jackets for calibers larger than .257” can be a straight taper but more often they have a base section that has a straight wall that is one-third to one-half the length of the jacket and then the wall tapers to the jacket mouth. This has the advantage of controlling expansion better than a straight taper jacket as the thicker base section tends to retard expansion and holds the bullet together better than a taper wall jacket. The tapered section lets the bullet be pointed up with less pressure while allowing a small meplat on the bullet. It is a good design if the jacket is long enough to allow it which is why this design is more common in the larger calibers.



A variation on the straight wall/tapered jacket has the jacket taper from the base to part way up the jacket. Then the jacket has a thinner straight wall out to the mouth of the jacket. This makes it a little easier for the bullet maker as only one core seating punch will be needed for most jacket lengths and core weight combinations. But it isn't as good of a jacket for hunting bullets as expansion is not as well controlled as with the jackets that have second type of jacket.

Tapered base jacket

A third variation on the straight wall/taper wall jacket is an odd combination that has a short tapered base section, a straight section in the middle of the jacket, and then a tapered section out to the jacket mouth. There is no particular advantage to this jacket and the drawing punches are more difficult to make. But it does demonstrate what can be done with deep drawing equipment.



Tapered base, straight middle, taper to mouth

To improve on expansion some jackets can have a polygon inside. The inside of the jacket will have a hexagon, octagon, or a polygon shape. The polygon shape weakens the jacket and aids in causing the jacket to expand easily at lower velocities. The polygon shape can be made in straight walled jackets or taper walled jackets. Sometimes the polygon area is short and is only near the mouth of the jacket with the rest of the jacket ID being round. This gives the benefit of the polygon to aid expansion while the round section allows for a simple core seating punch. Other jackets may have the polygon extend further down in the jacket or even to the bottom of the jacket. For these jackets a polygon core seating must be used. It is a much more difficult jacket to make but it can be worthwhile.

Other ways to improve expansion of the bullet or to make a frangible bullet include scoring the outside of the jacket, either for its entire length or only for a short distance from the jacket mouth down towards the jacket base. Some jackets can be scored internally and it is possible to notch or nick the mouth of the jacket to help to start expansion.

Making Jackets from Strip

Drawn jackets can be made from various materials but the most common material used by home or small commercial bullet and/or jacket makers is ordinary C110 pure copper. Gilding metal (95% copper/5% zinc) or C220, commercial bronze (90% copper/10% zinc), can also be used but finding a supplier for those materials and at an affordable price can be difficult. Copper is readily available and at a reasonable cost. As this is being written copper and copper alloys have taken a huge jump in cost but copper and copper alloys remain the first and best choices for bullet jackets.

The copper is usually available in large sheets or in huge rolls. These would be quite awkward to handle. The supplier can cut the copper into strips by that can be pulled through the blanking die. The strip width will be the diameter of the blank to be cut plus about one-sixteenth of an inch on each side of the blank. If the blank is to be 1.0" in diameter then the strip would be about 1 1/8" wide. In a commercial shop where many thousands of jackets are to be made it is important to use the narrowest strip that will still allow a good blank to be made. A savings of 1/32" on the width of the strip can save many tons of scrap. But for the home bullet/jacket maker or for a small producer the use of one width of strip can reduce the a number of strip widths stocked and improve cash flow. Limiting the amount of scrap is good but it isn't always the most important factor. Copper scrap has value and can be sold thus recovering some of the material cost.

The number of steps required to draw a jacket will depend on how long the finished jacket must be, its diameter, wall thickness and design, hardness of the material to be drawn, and other factors. It can be a little difficult to determine the number of steps needed without actually making up a set of drawing tools but as a general rule four to six operations will be needed to make most jackets.

The first step is to cut out a blank or disk of copper or other material. This is then drawn into a short, large diameter cup that has thick walls. The cup is then redrawn in several steps to reduce its diameter, thin the jacket wall, and lengthen the jacket. The jacket being drawn can be made with a tapered inside diameter (ID) or it can be a straight walled jacket. In addition the jacket can be made with a polygon shaped ID to improve expansion on game, it can be notched at the mouth, the jacket base can be flat, a boattail, or the base can be made rounded so that the base will eventually be the nose of the bullet to make solids for use against heavy dangerous game.

The last step in making a jacket from strip is to trim the jacket to length. As the jackets are drawn smaller and longer uneven lobes will develop at the mouth of the jacket. These lobes are called "ears". There are ways to try to control the formation of the ears but it is a problem that cannot be avoided completely. Trimming the jacket removes the uneven portion of the jacket and sets the jacket length. Most trim dies are adjustable so that almost any length jacket can be made. Trimming is normally done by using what is known as a pinch trim die. The jacket is pushed into a die that has a sharp cutting edge. As the jacket is pushed through the die a portion of the jacket is pinched between the cutting edge of the die and the punch so that the jacket is cut to the needed length.

Another way to trim jackets is to use a lathe that uses a collet to hold the jacket. A thin cut off blade is used to cut the jacket to length or a circular blade much like a tubing cutter can be used. Special trimming lathes are used in production to quickly cut the jackets to length but an ordinary metal working lathe can be used to cut small numbers of jackets.

Jackets can also be trimmed using a small cut-off saw that is equipped with fine tooth, high speed steel blades. This method will work reasonably well but if the saw blade runs at too high of an rpm the blades will become dull very rapidly.

The dies used to redraw the jacket can be a very simple design or may be much more complex. If the jacket is only going to be reduced in diameter a small amount and little wall thinning is to be done the redraw die can be made out of one solid piece of tool steel and a simple draw punch can be used. A better method is to use a simple redraw die with a punch that has a locator nest or guide bushing that is spring loaded and moves up and down on the punch. The nest helps to keep the jacket to be redrawn aligned to the die so that truer draws can be done.

If much thinning or size reduction is to be done the redraw die is usually made to fit in a die holder. A nest die is placed in the die holder before the redraw die and aligns the jacket to the redraw die. The die holder will usually be equipped with some sort of positive stripper device that removes or strips the redrawn jacket from the punch. Sometimes the jacket is removed from the punch below the die holder but more often the jacket is pushed through the die holder and removed from the punch above the die holder. Because the redraw die set is longer than the simple redraw die a longer draw punch is needed. This means that the press used must have a long stroke length and must have adequate power from the beginning of the draw to the end of the draw. A hydraulic press or other type of powered press must be used.

Hand operated presses are mostly useful when redrawing short jackets. Redrawing long jackets can be done using a hand press by partly drawing the jacket, then the press ram lowered and a "helper rod" is placed in the jacket, and the press ram is moved up again to finish drawing the jacket. This method works but it is slow and long jackets are usually best drawn in one stroke.

Once the jackets have been drawn and trimmed they usually need to be annealed. Annealing the jacket helps to reduce the pressure needed to seat the lead core in the jacket, it aids in keeping the jacket from cracking and folding up when the bullet is pointed up, and helps the bullet to expand more reliably. It is important not to anneal the jacket at too high of a temperature. As a rule 800 degrees Fahrenheit will be enough but it may be necessary to adjust the anneal temp to give the wanted results. Too high of an anneal can cause the jackets to be too soft and can contribute to the jacket buckling and shortening when the bullet is pointed up.

The finished jackets can be tumbled in crushed corn cobs or walnut shells to improve the appearance but never use any abrasive media. The abrasive can case damage to the dies and even the gun barrel.

Extruded Jackets

Jackets can also be made by using a process called extruding. Extruding is a simple process that is used to produce many different kinds of parts. When a toothpaste tube is squeezed the paste flows out of a small orifice at the end of the tube. This is a basic extrusion process. Pressure is applied to the toothpaste tube (the die body) and the paste moves out the end of the tube (the extrusion die).

Soft materials such as toothpaste or lead can be extruded in small quantities with relatively little pressure. Lead wire can be extruded using a small hydraulic press. Harder materials such as steel or copper alloys require the use of many, many tons of force, even to make parts with a simple shape. This equipment is well beyond what a home or small commercial shop can afford or use.

To extrude something a die holder or die body is made that contains the material to be extruded. A snug fitting punch enters one end of the holder and an extrusion die is at the other end of the holder. The extrusion die can be a simple polished hole such as would be used to make lead wire or the die can be quite complex. Lead wire channel used in stained glass work is made by extruding it.

So far the discussion has been about “forward extrusion”. Forward extrusion is when the material is forced ahead of the punch. Forward extrusion can be used to make parts that are solid, have a hole or holes in them, have multiple diameters, and the part can be round, square, or any other shape. But forward extrusion can also be used to make a tube that has a closed base, that is a bullet jacket. Tremendous pressured is used to force the copper or copper alloy to move forward in a die and around a punch that is in the end of the die. This forms the bullet jacket which is then pushed out of the die and is ready to be used.

It is also possible to do “backward extrusion”. Backward extrusion causes the material to flow back up and around the punch that applies pressure to the material. The end result is the same with a bullet jacket being formed. Whether to use backward or forward extrusion depends on the material to be extruded, the type of machine used, the tooling, and the experience and knowledge of the toolmaker.

Sometimes forward and backward extrusion are combined to produce a part that has two formed ends. The ends can be the same or quite different. The process increases the number of parts that can be produced on a single machine and die set but does require a machine with much greater power. Partition bullet jackets can be made using a combined extrusion process.

To make a bullet jacket a piece of copper or copper alloy wire is cut to the correct length. The slug is then pressed in a die that flattens and squares up the ends of the slug. The slug is annealed to soften it and is cleaned. Sometimes an acid “pickle” is used to clean the slug and leave the surface slightly etched so that forming lubricant will be more effective. The slug is then extruded in several dies. Depending on the severity of the extrusion additional anneals may be required. Eventually the jacket is fully extruded and is ready to be used. A trim operation may be needed to insure the ends of the jacket are square and to adjust the jacket length. The process is expensive and requires some serious machinery but does produce very good jackets.

Machined Jackets

Another way to make a good quality jacket is to machine it from solid rod. This is a somewhat costly method as there is more scrap produced in making the jacket and the copper rod is more expensive than strip. Not to mention that the machining time must also be considered in the price of the jacket. But it is a good process for making thicker jackets or special jackets for hunting bullets or if the jacket must have a shape that cannot easily be produced using a drawn or extruded jacket.

Machining jackets from rod is also practical for the home or small commercial shop.

Jackets can be made from pure copper rod but more often an alloy such as Tellurium copper or leaded copper is used. Copper that is alloyed with lead or Tellurium will machine much easier than pure copper and will usually have a better appearance than pure copper. The cost of the alloy copper is more but it is often offset by the lower cost of machining it.

The jacket can be produced using a simple metal cutting lathe, a turret lathe, or a screw machine. The metal cutting lathe will do a good job but it is slow even if the lathe is equipped with collets and a lever type collet closer.

A small turret lathe will speed the job up considerably and make it possible to produce enough jackets for limited sales. A turret lathe has a hexagon tailstock, a turret, that can hold several tools. The turret can be rotated so that each tool can be used to machine the jacket. The turret has a stop for each position that enables the depth of the cut to be the same each time. In addition the cross-slide on the turret lathe can hold a single or multiple tool holder on the rear and front ends of the cross-slide. This permits several more cutting tools to be mounted and used as needed. Jackets can be quickly made using such a machine but the machines are somewhat expensive although good used turret lathes can be found at reasonable prices.

The screw machine is ideal for making jackets. These machines were originally designed to make small parts such as screws which is where their name came from. Older machines used a number of cams to move the cutting tools in and out of the work-piece. The machine will run automatically, making jackets all by itself until the length of rod is used up. Some screw machines will even load a new rod of material from a magazine by the machine so that work will continue until the magazine of stock is used up or until the operator turns the machine off. Even the old screw machines are in demand and their cost is fairly high.

A newer machine is the CNC screw machine as well as the CNC lathe. Both of these machines use a computer to tell the machine what to do so that there is no laborious and very skilled grinding of cams. A machine programmer simply writes a program that tells the machine what to do and parts are made. It is a bit more complicated than that but a skilled programmer can write the machine's instructions pretty quickly, and after running a few test parts, jackets can be quickly produced.

The finished jacket may need to be annealed if it is to be used for a hunting bullet but often no anneal is required. The jacket can be a very simple tube similar to a drawn jacket or it can be much more complex.

A jacket that has a straight wall can be threaded on the inside to help hold the core in place or grooves can be cut in the jacket interior to anchor the core. With the correct tooling hexagon, octagon, or a polygon interior can be made. The outside of the jacket can be left smooth or grooves can be cut in it to reduce friction and pressure in the gun barrel. The possibilities are pretty much up to the person designing the jacket but it should be remembered that simple designs are often better than complicated designs and the more machining that must be done the more costly the jacket will be.