March 13, 2019 Meeting

The March 13, 2019 Waterloo Technical Society (WTS) meeting was called to order by Vice President Stevenson at 7:25 pm. Vice President Stevenson welcomed visitors and noted that this was the sixth meeting of the 105th year of the Society.

A total of 28 members and guests attended.

Treasurer's Report. Ken Friend reported a beginning balance of $975.17. Income of $20.00 from memberships with expenses of $40.00 for the February speaker's meal, and $117.70 for a funeral spray for Gary Dorhout's funeral leaving a new balance of $837.47. Treasurer Friend's report stated a total of 8 honorary and 40 paid members yielding a membership roster of 48 members.

Current Officers. Officers for the 2018-2019 year (year 105) are:

President:	Vacant (Gary Dorhout resigned due to poor health)
Co-Vice Presidents:	Jerry Mohling and James Stevenson
Treasurer:	Kenneth Friend & Paul Anderson
Dinner Reservations:	Derek Eagles & Steve Lang
Secretary:	James Stevenson
Publicity/Recognition:	Todd Whiting
Auditing:	Bill Mitchell & Jim Garrett
Nominating Committee:	Open
Web Site:	Tim Schoenfelder / Jim Volgarino

Old Business. The topics for this year were reviewed. The dates, speaker and topics for the 105th WTS are:
Speakers for the 2018-2019 Meeting Year (Year 105)

12 Sep 2018—Austin Maginnis—Tiny House Project at UNI

10 Oct 2018 – Steve Lang – Early Electronic Digital Computers

14 Nov 2018 – Jim Volgarino – History of Tunis Speedway

9 Jan 2019 – Chuck Nielson – Airgas Gas Supply

13 Feb 2019 – Chad Emerson – Emerson Crane

13 Mar 2019 – Vasko Popovski – Aspects of Heat Treatment in Firearm Components, AHT (Mike Woods)

10 Apr 2019 – Mark Albright—MidAmerica Energy, LNG Waterloo, Tom P.

8 May 2019 – AECOM Engineering Services, Waterloo, IA

(Architecture, Engineering, Construction and Operations Management)

Discussion on the May 2018 motion to donate $250 to Tiny House Program at UNI concluded with a decision to identify where donations have been made and prioritize alternatives for donations for action at the November 14, 2018 meeting. President Dorhout and Treasurer Friend are to make a list and members to identify possible recipients. Item tabled until the January 2019 meeting. No discussion on this topic. Tabled until February 13, 2019 meeting.

New Business. No new business discussed.

Guest Speaker. **Vasko Popovski**, Regional Sales Manager at Advanced Heat Treat Corp., has over 26 years of experience in heat treatment, metallurgy and engineering. Vasko received a Bachelor of Science degree in Metallurgical Engineering and a Bachelor of Arts degree in Economics from the University of Pittsburgh. He also has Master of Arts degree in Technology from Kent State University and an MBA from Waynesburg University. Vasko is a licensed Professional Engineer in Wisconsin, Ohio, and Pennsylvania. He has published numerous technical papers and chaired multiple industry committees



Vasko covers the Northeast USA, from Ohio to the Atlantic. Ontario, Canada also lands in this territory. Most of his work is associated with UltraGlow® Ion Nitriding, UltraGlow® Gas Nitriding, and UltraOx® processes.

In his free time Vasko enjoys spending time with his family. He enjoys trap shooting, live music of any kind, live theater and live sporting events. He also thinks it's important to be among people in our digital age.



Figure 1. Identification of the parts of a shotgun.

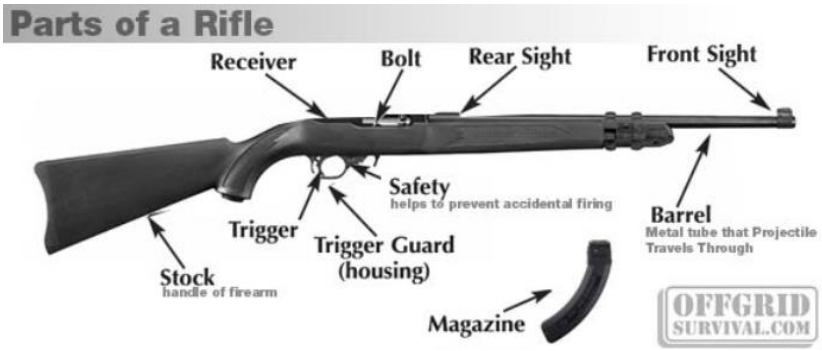


Figure 2. Identification of the parts of a rifle.



Figure 3. Identification of the parts of a handgun.

The act of discharging a firearm is inherently damaging to the unit itself. Also, operators rely on firearms to perform properly under adverse conditions. With these things in mind, manufacturers employ various heat treatments to firearm components. Vasko presented certain technologies aimed at protecting and improving forearm performance via heat treatment.

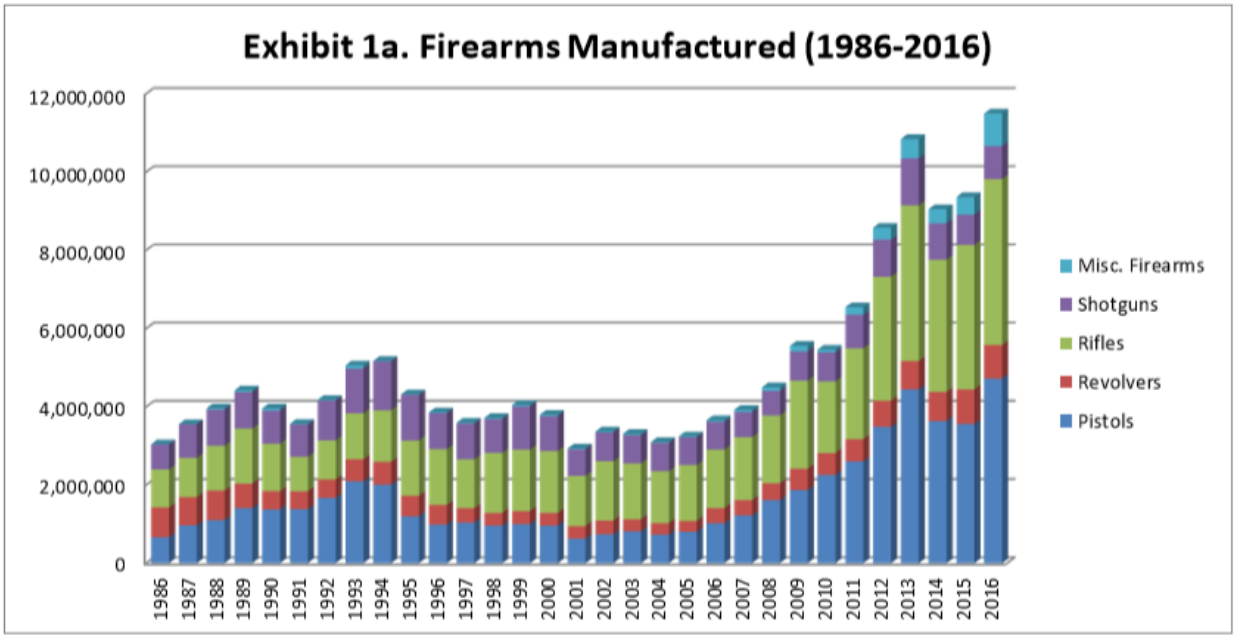


Figure 4. Firearms manufactured have increased at an increasing rate. Advanced Heat Treatment has had increasing interest in heat treating rifle barrels in the AR15 semi-automatic class.

Why heat treat the firearm barrel? The key properties of a barrel are:

Strength: gas temperature when a ballistic is fired is in the 3,000 to 4,000 °F range.
Barrel temperature: the barrel is heated to 1,000 °F during firing.
Pressure: pressures reach 50,000 to 70,000 psi during firing.
Environment: firearms are used in sunshine, rain, and snow.

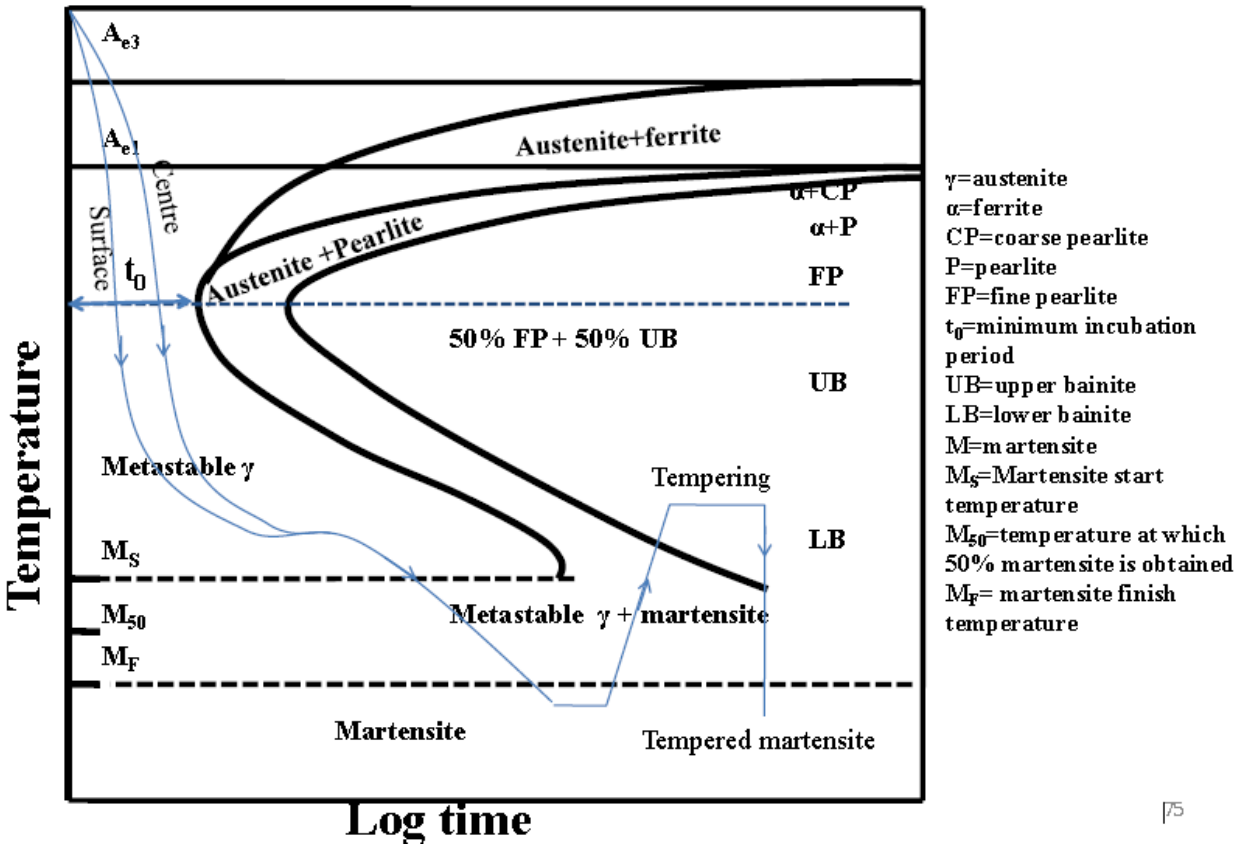


Figure 5. Hardness is a key indicator of strength. Appendix B explains how heat treatment can change steel hardness.

Strength is gained by hardening steel through case or surface hardening. Table 1 compares the two general methods.

Table 1. Comparison of case and surface hardening methods.

CASE HARDENING versus SURFACE HARDENING	
Case hardening is the process of hardening the surface of a metal by infusing elements onto the metal surface, forming a thin layer of a harder alloy.	Surface hardening is the process of increasing the hardness of the outer surface while the core remains soft.
Done by red heating the steel, infusing carbon onto the surface and quickly quenching.	Done by heating the steel up to austenitizing temperature while keeping the core below that temperature and quenching the surface immediately.
Commonly used for low carbon metal allow such as mild steel.	Used for many equipment made from steel.
Does not require immediate quenching.	Requires immediate quenching.

Wear can be improved through processes like nitriding that occurs at lower temperatures so there is less distortion. The case depth is typically 0.040 to 0.060 inches. Ultra-glow™ and plasma nitriding at case depths of 0.002 to 0.020 are also used when minimal distortion is required.

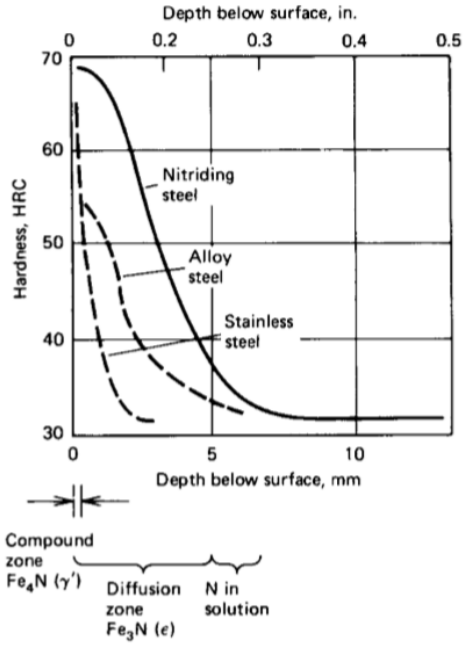


Figure 6. Case depth for nitriding, alloy, and stainless steel. Deeper cases usually accompany greater distortion.

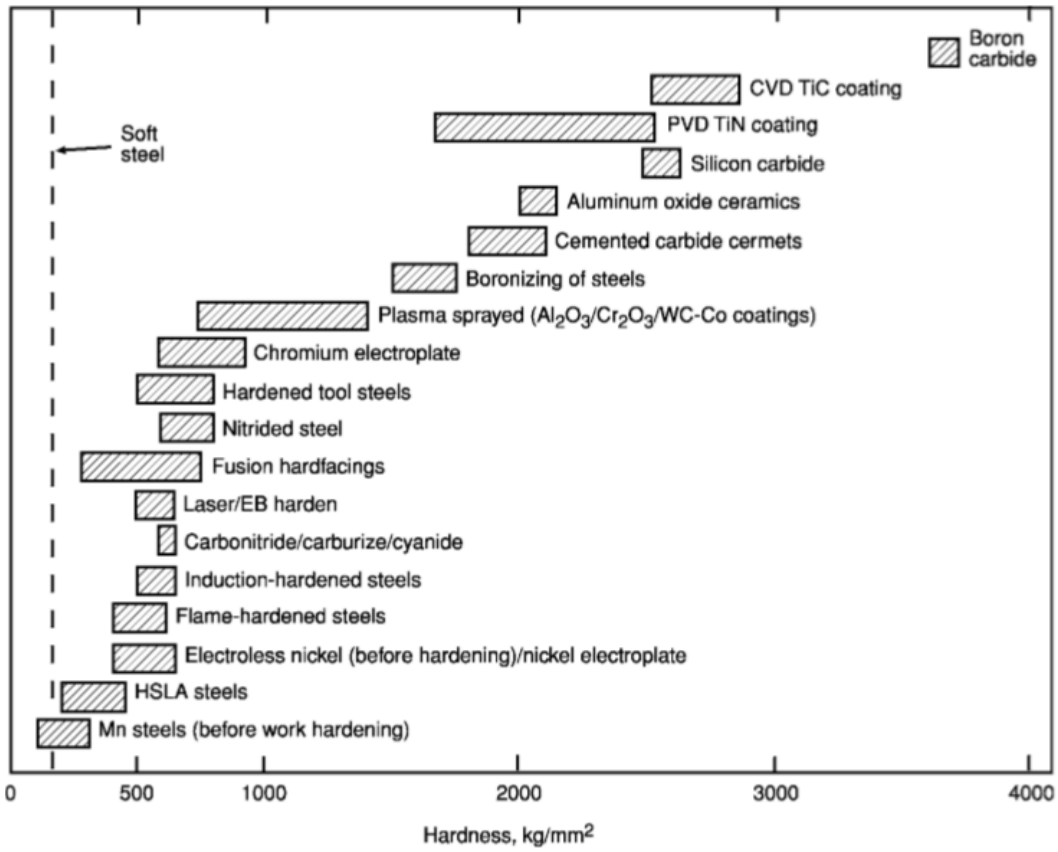


Figure 7. Hardness obtained using various steels and heat treat processes.

Ultra-Ox™ provides a sleek black finish for wear resistance. It is environmentally friendly and replaces chrome surface plating. The oxide depth is 0.00004 to 0.00008 inch (1 to 2 micron). The customer should specify the resulting case depth rather than the process. Ultra-Ox™ provides better corrosion and pitting resistance than chrome plating. ASTM G61 Standard Test Method for Conducting Cyclic Potentiodynamic Polarization Measurements for Localized Corrosion Susceptibility of Iron-, Nickel-, or Cobalt-Based Alloys is used to evaluate coatings and the Ultra-Ox™ results are superior to chrome plating.

For more information on heat treatment at Advanced Heat Treat visit their web site at www.ahtweb.com.

Meeting adjourned at 8:30 pm.

Next Meeting. The next meeting will be April 10, 2019. Mark Albright and Tom Pfiffner, MidAmerica Energy, will speak about Liquified Natural Gas.

Respectfully submitted,

James R. Stevenson, Vice President and Secretary

Appendix A: Rifle Barrel Creation Process

Most rifle and handgun barrels (save those intended for hammer forging) start life as a cylindrical steel bar about 1 inch thick and 12 or more feet long, obtained from a steel mill. Each barrelmaker or gun manufacturer specifies the exact grade and composition of steel to be used in order to obtain the desired combination of physical properties. Often the steel bars are stress-relieved before leaving the steel mill. Many shotgun barrels begin as thick-walled, seamless steel tubing.

Initial Trueing. At the barrelmaker's, the bar is cut into lengths of 28 to 30 inches, then turned on a lathe to face the ends off square and give the exterior a uniform roundness. If the steel was not stress-relieved at the mill, it may be given such treatment at this point by heating in a furnace to 600 degrees Fahrenheit and then cooling over a period of hours.

Deep-Hole Drilling. Next, the trued, stress-relieved bar is drilled using a long drill with a hollow stem and a tungsten-carbide bit, having a single cutting tooth on only one side. Under high pressure, cutting oil is forced through the hollow stem to cool the cutting tooth and to flush chips away. Some drilling machines spin the drill, some the barrel, and some spin both in opposite directions. Drilling a 28-inch or 30-inch-long hole that is uniform in diameter, smooth, and straight to within .0005 inches or so throughout its length is the most difficult part of the barrel-making operation. Most barrels that are to be button, broach or cut-rifled are drilled several thousandths under bore size.

Reaming. To bring the drilled hole to the proper diameter with a smooth interior surface finish, the drilled hole is now reamed. Care must be taken not to leave reamer marks on the bore surface in this step. Chatter marks from a dull or improperly used reamer are common defects.

Rifling. When the hole is straight and uniform, the next step is to put the rifling grooves in the bore using one of several methods. The most common methods of rifling a barrel include cut, broach or button rifling.

Air-Gauging. After rifling, the bore may be subjected to an air-gauge examination. An air gauge is a precision measuring instrument that uses a snug-fitting probe sensitive enough to detect extremely small inconsistencies in bore diameter as it travels through the barrel.

Straightening. At this point, the barrel may not be perfectly straight as a result of the stresses imposed by the various machining processes, or from a change in pre-existing internal stresses. Barrels can be straightened by an experienced craftsman using a turret press.

Lapping. To remove the small inconsistencies remaining in the bore, barrels are lapped as a final step. The lapping process involves pouring a small amount of molten lead into the bore to create a plug that fills the bore perfectly. The plug is coated with lapping abrasive and run back and forth in the bore using a metal rod. Depending upon the fineness of the abrasive, the lapping process will eliminate tight spots and take the interior finish to a mirror-like polish. Lapping is often performed after final contouring, as bore diameter may grow slightly when metal is removed from the outside of the barrel. Lapping is a time-consuming process usually only performed on match-grade barrels. The bores of factory production barrels are rarely, if ever, lapped.

Stress Relief. As a final step, virtually all aftermarket barrel manufacturers and many commercial gunmakers stress-relieve finished barrels to remove internal stresses that can cause warping and wandering points of

impact as the barrel heats up. Most stress-relieving methods utilize conventional heat treating at elevating temperatures, as described earlier. Cryogenic stress relief is also popular, although some manufacturers feel it does little for certain types of steel.

The end result, the rifled cylindrical bar, is called a barrel blank. It will undergo additional operations such as chambering, head spacing, crowning, threading and/or further contouring and polishing before it begins service as a barrel.

Note that the above sequence is a description of the procedure used to produce a cylindrical barrel for a bolt-action rifle, and may not be a complete description for all barrels. Many barrels for handguns and semi-automatic rifles, for example, have complex profiles for locking lugs, sights, gas blocks and so forth that require more than just lathe work. The basic steps in barrel production are still followed, however.

Appendix B: Heat Treatment Basics

Heat treatment provides stress relief and stabilization. A typical stress is imparted by welding. Some of the material is heated up to 1,600 degrees F, maybe as high as 2,000 degrees F, but material nearby is room temperature. When it cools, you have normal material [that remained at room temperature] and a heat-affected zone. The heat-affected zone is like a crease in a sheet of paper. If a tear starts there, it propagates along the crease or that zone. Welding isn't the only process that does this. Machining, stamping, drilling, and other metalworking processes leave unique stresses too.

Successful heat treatment requires raising the material to the right temperature, soaking it at that temperature for the right amount of time, and cooling it appropriately.

Surface Hardening

Heat treatment methods in general change the properties of the entire material. Hardening improves the wear resistance of material, but lowers impact resistance and fatigue life. Therefore sometimes there is a requirement to surface harden. Two methods are used, first is heating and cooling to get the required crystal phase, and second is thermo-chemical treatment:

Induction heating
Flame hardening
High frequency resistance heating
Laser beam hardening
Electron beam hardening
Carburizing
Nitriding
Cyaniding

Enter the Heat-treating Furnace. Thermal treatments help to overcome these defects, getting the material closer to a symmetric, homogenous structure and reducing internal stresses. Heat treating elevates the temperature, making the atoms more mobile. It imparts enough heat to make the atoms move around again, allowing them to realign themselves. Slow cooling decreases the boundaries between grains, providing a more uniform crystal lattice. It also reduces internal stresses, thereby increasing the metal's stability.

As a metal cools from a liquid state to a solid state, the atoms arrange themselves in a specific, ordered pattern, also known as a *crystal structure* or *crystal lattice structure*. Steel's structure commonly is cubic. A cube with nine atoms, one in each corner and one in the center, is said to have a *body-centered cubic* (BCC) structure (see **Figure 8**).

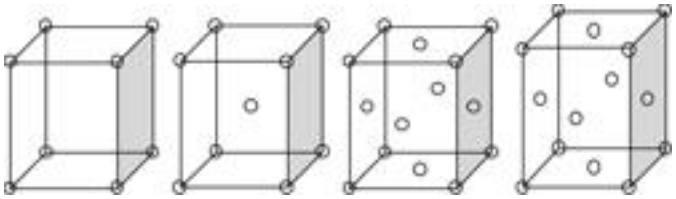


Figure 8 The leftmost diagram illustrates a theoretical cubic structure. Two cubic steel structures are body-centered cubic (BCC), also known as ferrite (second from left), and face-centered cubic (FCC), which is austenite (third from left). The face-centered tetragonal (FCT) structure, far right, is known as martensite. The FCT structure is about 14 percent larger than the FCC structure.

A cube with 14 atoms, one in each corner and one in the center of each face of the cube, is face-centered cubic (FCC). Another structure for steel is a tetragon, which has right angles like a cube, but the sides are not equal lengths.

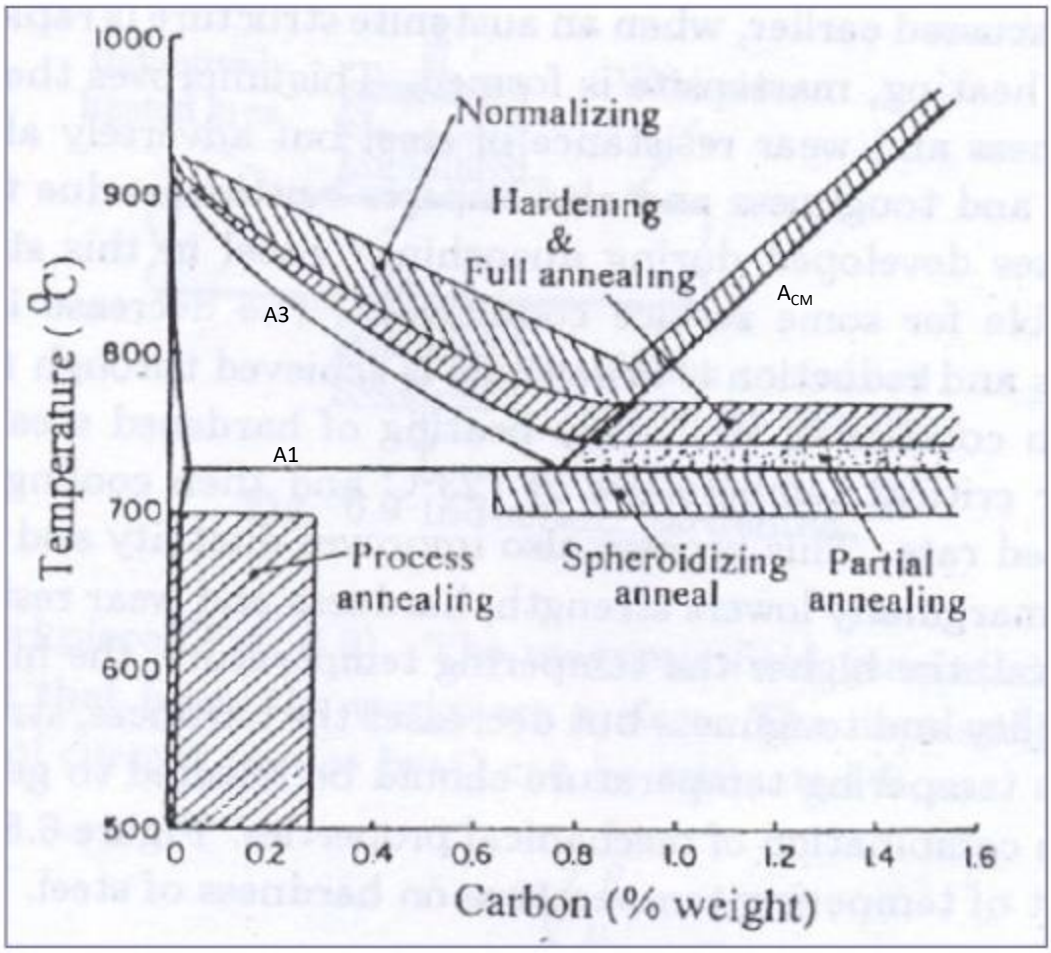


Figure 9. **A low-carbon steel alloy changes from ferrite to austenite as its temperature increases, and the amount of carbon determines the temperature at which these changes occur. It doesn't change suddenly or completely; steel transforms bit by bit, taking some time to change from primarily ferrite to primarily austenite and so on.**

Heat treatment of metal is done by raising the temperature to a point where there is a change in the crystal structure of the metal (an expert can look under a microscope and see what has been done). But the actual crystal structure is on a molecular level. Depending on what you are trying to do, the metal is either quenched to prevent the crystal structure from changing, or allowed to cool slowly.

Crystal structure is different depending on whether it was cast, forged, or tempered in the first place. Button rifling is basically a forging process and can put stress in the barrel, and the heat treatment can remove that stress by bringing it back to its pre-forged condition.

Full annealing is the process of slowly raising the temperature about 50 ºC (122 ºF) above the *Austenitic temperature* line A3 or line A_{CM} in the case of Hypoeutectoid steels (steels with < 0.77% Carbon) and 50 ºC (122 ºF) into the Austenite-Cementite region in the case of Hypereutectoid steels (steels with > 0.77% Carbon).

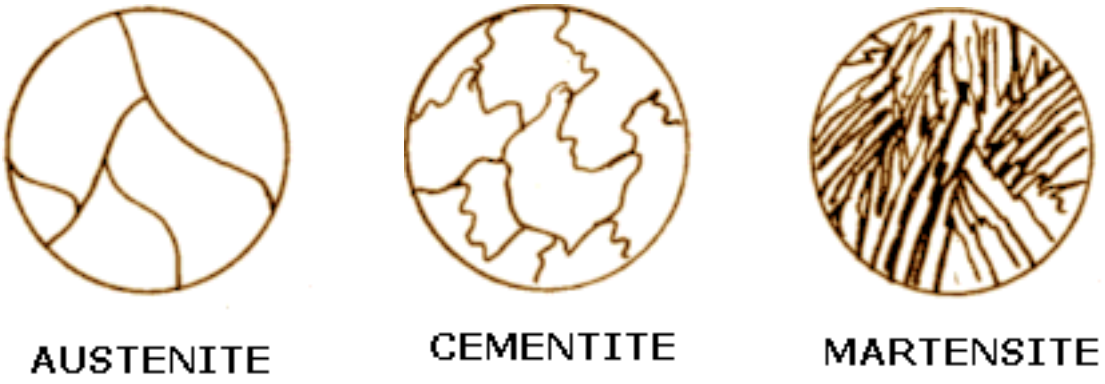


Figure 10. **Grain structure of three forms of steel.**

It is held at this temperature for sufficient time for all the material to transform into Austenite or Austenite-Cementite as the case may be. It is then slowly cooled at the rate of about 20 ºC/hr (36 ºF/hr) in a furnace to about 50 ºC (122 ºF) into the Ferrite-Cementite range. At this point, it can be cooled in room temperature air with natural convection.

The grain structure has coarse Pearlite with ferrite or Cementite (depending on whether hypo or hyper eutectoid). The steel becomes soft and ductile.

Normalizing is the process of raising the temperature to over 60 º C (140 ºF), above line A3 or line A_{CM} fully into the Austenite range. It is held at this temperature to fully convert the structure into Austenite, and then removed from the furnace and cooled at room temperature under natural convection. This results in a grain structure of fine Pearlite with excess of Ferrite or Cementite. The resulting material is soft; the degree of softness depends on the actual ambient conditions of cooling. This process is considerably cheaper than full annealing since there is not the added cost of controlled furnace cooling.

The main difference between full annealing and normalizing is that fully annealed parts are uniform in softness (and machinablilty) throughout the entire part; since the entire part is exposed to the controlled furnace cooling. In the case of the normalized part, depending on the part geometry, the cooling is non-uniform resulting in non-uniform material properties across the part. This may not be desirable if further machining is desired, since it makes the machining job somewhat unpredictable. In such a case it is better to do full annealing.

Process Annealing is used to treat work-hardened parts made out of low-Carbon steels (< 0.25% Carbon). This allows the parts to be soft enough to undergo further cold working without fracturing. Process annealing is done by raising the temperature to just below the Ferrite-Austenite region, line A1on the diagram. This temperature is about 727 ºC (1341 ºF) so heating it to about 700 ºC (1292 ºF) should suffice. This is held long enough to allow recrystallization of the ferrite phase, and then cooled in still air. Since the material stays in the same phase throughout the process, the only change that occurs is the size, shape and distribution of the grain structure. This process is cheaper than either full annealing or normalizing since the material is not heated to a very high temperature or cooled in a furnace.

Stress Relief Anneal is used to *reduce residual stresses* in large castings, welded parts and cold-formed parts. Such parts tend to have stresses due to thermal cycling or work hardening. Parts are heated to temperatures of up to 600 - 650 ºC (1112 - 1202 ºF), and held for an extended time (about 1 hour or more) and then slowly cooled in still air.

Spheroidization is an annealing process used for high carbon steels (Carbon > 0.6%) that will be machined or cold formed subsequently. This is done by one of the following ways:

1. Heat the part to a temperature just below the Ferrite-Austenite line, line A1 or below the Austenite-Cementite line, essentially below the 727 ºC (1340 ºF) line. Hold the temperature for a prolonged time and follow by fairly slow cooling. Or
2. Cycle multiple times between temperatures slightly above and slightly below the 727 ºC (1340 ºF) line, say for example between 700 and 750 ºC (1292 - 1382 ºF), and slow cool. Or
3. For tool and alloy steels heat to 750 to 800 ºC (1382-1472 ºF) and hold for several hours followed by slow cooling.

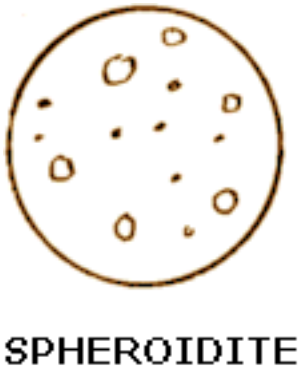
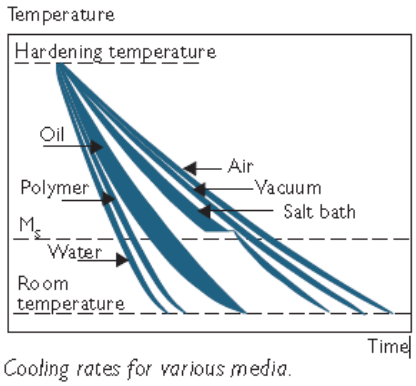


Figure 11. Spheroidite grain structure improves machinability and resistance to abrasion.

All these methods result in a structure in which all the Cementite is in the form of small globules (spheroids) dispersed throughout the ferrite matrix. This structure allows for improved machining in continuous cutting operations such as lathes and screw machines. Spheroidization also improves resistance to abrasion.

Quenching steel while it is hot hardens the steel, but it can also make it brittle, so you have to know the right temperature for the application. Often a tempered steel piece is added to a forged piece for toughness (wood cutting chisels for example).



Cooling rates for various media.

Figure 12. Quenching rates in various quenching liquids.

Quenches are usually done to room temperature. Most medium carbon steels and low alloy steels undergo transformation to 100 % Martensite at room temperature. However, high carbon and high alloy steels have *retained Austenite* at room temperature. To eliminate retained Austenite, the temperature has to be lowered.

Cryogenics, or deep freezing is done to make sure there is no *retained Austenite* during quenching. In Cryogenic treatment the material is subject to deep freeze temperatures of as low as -185°C (-301°F), but usually -75°C (-103°F) is sufficient. The Austenite is unstable at this temperature, and the whole structures becomes Martensite. This is the reason to use Cryogenic treatment. When steel is at the hardening temperature, there is a solid solution of Carbon and Iron, known as Austenite. The amount of Martensite formed at quenching is a function of the lowest temperature encountered. At any given temperature of quenching there is a certain amount of Martensite and the balance is untransformed Austenite. This untransformed austenite is very brittle and can cause loss of strength or hardness, dimensional instability, or cracking.

Coating. Chrome-lined bores are actually coated and most companies are unable to do this uniformly.

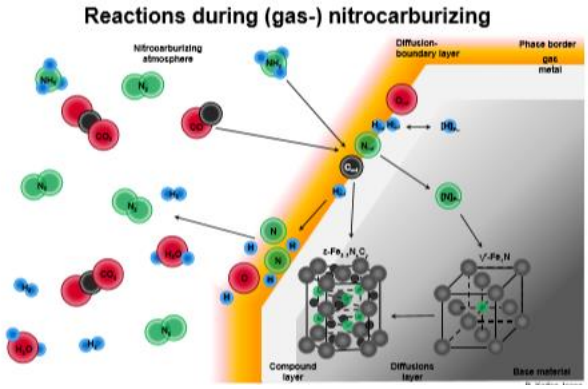


Figure 13. **Illustration of ion exchange at the metal surface during nitrocarburizing.**

Nitriding does not add a coating, rather, it changes the surface properties by diffusing nitrogen and carbon into the metal surface to yield an extremely smooth, uniform and wear-resistant bore. Chrome-lined barrels still need outer surface protection, normally achieved by some manner of Parkerization. Since the hot liquids used in nitriding flow over all exposed surfaces in a bath, the entire barrel gets a very durable layer of protection against corrosion. A barrel that is to be chromed has to be drilled, rifled and chambered slightly oversize to account for the thickness of the chrome lining. Nitriding does not change any dimensions, so it can be applied to finished barrels.

Imperfections in the Structure. Metal's crystal structure is not uniform. The processes used to turn a metal into a useful form, whether by casting, forging, or rolling, introduce imperfections in the metals' structure. Discontinuities, variations in spacing, and other imperfections are unavoidable. These problems are compounded by processes such as grinding, machining, and drilling, which impart additional internal stresses.

Furthermore, a close examination of a cross section reveals imperfections, microvoids, and interstitials throughout the material.

Heat Treating and Cryogenic Processing of Firearm Steel

Allowing steel heated to its austenitizing temperature to cool slowly to room temperature would turn it into ferrite. Quenching it at the martensitizing temperature prevents this; the rapid change in temperature prevents it from returning to the BCC structure. This is the goal of heat-treating firearm steel.

When you heat-treat firearm steel, you're striving for a full transformation. You want to change all of the austenite to martensite. If the temperatures are right and the heat-treater does the draws appropriately, and everything is done correctly, most firearm steels harden up to about 99.7 percent martensite.

The pockets of retained austenite are weak spots in the material.

If it is roll tooling, the friction removes that little bit of austenite, and if it's slitter tooling, the compressive load causes fractures to appear. Once it starts to deteriorate, it's like a pothole in the road—continued stresses cause the hole to grow quickly.

This is where cryogenic processing, a member of the family of thermal processes, can help.

This is a continuation of the heat-treating process. Heat-treaters take the material from room temperature to a high temperature, then back to room temperature. They take it from room temperature to -300 degrees F and back to room temperature.

The cryogenic process is actually a more sophisticated process than that, starting with raising the temperature to 200 degrees F, dropping it to -300 degrees F, then usually back to +300 degrees F, then to room temperature. The final portion is necessary to finalize the process. Taking it down to -300 degrees produces fresh martensite, which is brittle. Taking it up to 300 degrees stabilizes it."

If the material is steel and it has some retained austenite, the austenite will continue to convert to martensite at room temperature. Because the martensitic structure is slightly larger than the austenite it replaces, the material actually changes size. The change is small and it occurs slowly, but it is measurable.