Abdulla Aljunibi

PROPERTIES OF METALS

aircraft maintenance are such general properties of metals and their alloys as:

hardness, malleability, ductility, elasticity, toughness, density, brittleness, fusibility, conductivity contraction and expansion,

STRENGTH

Strength is the ability of a material to resist deformation.

Strength is also the ability of a material to resist stress without breaking.

DENSITY

Density is the weight of a unit volume of a material

Density is an important consideration when choosing a material to be used in the design of a part in order to maintain the proper weight and balance of the aircraft

Less density – less weight

HARDNESS

Hardness refers to the ability of a material to resist

Hardness refers to the ability of a material to resist:
abrasion, penetration, cutting action, or permanent distortion.

Hardness may be increased by:
heat treatment
cold working

MALLEA'BILITY

metal which can be :
hammered, rolled, or pressed into various shapes without cracking, breaking, or leaving some other detrimental eff ct, is said to be malleable
Copper is an example of a malleable metal.

DUCTILITY

property of a metal which permits it to be permanently: drawn, bent, or twisted into various shapes without breaking.

Ductile metals are greatly preferred for aircraft use because of their ease of forming and resistance to failure under shock loads

ELASTICITY

is that property that enables a metal to return to its original size and shape when the force which causes the change of shape is removed.

This property is very valuable it would be highly undesirable to have a part permanently distorted after an applied load was removed.
Each metal has a point known as the elastic limit

TOUGHNESS

toughness will withstand:
tearing or shearing and may be stretched or otherwise deformed without breaking

BRITTLENESS

is the property of a metal which allows little bending or deformation without shattering.
M
brittle metal is apt to break or crack without change of shape

FUSIBILITY

Fusibility is the ability of a metal to become liquid by the application of heat. Metals are fused in welding. Steels fuse around 1 425°C (2 600°F) and aluminum alloys at approximately 600°C (1 100°F).

Ductility is similar to malleability.

CONDUCTIVITY

Conductivity is the property which enables a metal to carry heat or electricity

heat conductivity of a metal is especially important in welding because it governs the amount of heat

aircraft, electrical conductivity must also be considered in conjunction with bonding to eliminate radio interference.

THERMAL EXPANSION

Thermal expansion refers to contraction and expansion that are reactions produced in metals as the result of heating or cooling.

Heat applied to a metal will cause it to expand or become larger.

TYPES OF FERROUS METALS

The term "ferrous" applies to the group of metals having iron as their principal constituent

IRON

carbon is added to iron approximately 1 percent

the product is vastly superior to iron alone and is classified as carbon steel.

carbon steel with other elements known to improve the properties of steel.

A base metal (such as iron) to which small quantities of other metals have been added is called an alloy

STEEL AND STEEL ALLOYS

numerical index:to know which known the material

four numeral series is used to designate the plain carbon and alloy steels

five numerals are used to designate certain types of alloy steels.

The first two digits indicate the type of steel,

the second digit also generally (but not always) gives the approximate amount of the major alloying element

and the last two (or three) digits are intended to indicate the approximate middle of the carbon range

M

These elements are considered as incidental and may be present to the maximum amounts as follows: copper, 0.35 percent; nickel, 0.25 percent; chromium, 0.20 percent; molybdenum, 0.06 percent.

Metal stock is manufactured in several forms and shapes, including sheets, bars, rods, tubing, extrusions, forgings, and castings.

M 15. The casting is finished by machining.

Spark testing is a common means of identifying various ferrous metals.

In this test the piece of iron or steel is held against a revolving grinding stone and the metal is identified by the sparks thrown off Each ferrous metal has its own peculiar spark characteristics M

spark testing is often inexact unless performed by an experienced person,

1, Wrought iron produces long shafts that are straw colored as they leave the stone and white at the end.

2, Cast iron sparks are red they leave the stone and turn to a straw color.

3, Low carbon steels give off long, straight shafts having a few white sprigs

As the carbon content of the steel increases, the number of sprigs along each shaft increases and the stream becomes whiter in color.

4, Nickel steel causes the spark stream to contain small white blocks of light within the main burst

TYPES OF ALLOYED STEEL

1, CARBON STEEL :

Steel containing carbon in percentages ranging from 0.10 to 0.30 percent is classed as low carbon steel.

The equivalent SAE numbers range from 1010 to 1030.

Steels of this grade are used for making such items as: safety wire, certain nuts, cable bushings, or threaded rod ends.

steel in sheet form is used for: secondary structural parts and clamps, and in tubular form for moderately stressed structural parts

Steel containing carbon in percentages ranging from 0.30 to 0.50 percent is classed as medium carbon steel.

1, This steel is especially adaptable for machining or forging, and where surface hardness is desirable.
2, Certain rod ends and light forgings are made from SAE 1035 steel.

Steel containing carbon in percentages ranging from 0.50 to 1.05 percent is classed as high carbon steel.

adds to the hardness of this steel.

In the fully heat treated condition it is very hard, will withstand high shear and wear, and will have little deformation

M : SAE 1095

2, NICKEL STEEL:
nickel steels are produced by combining nickel with carbon steel

Steels containing from 3 to 3.75 percent nickel are commonly used

Nickel increases:
1, the hardness
2, tensile strength
3, elastic limit of steel without decreasing the ductility
4, intensifies the hardening eff ct of heat treatment

SAE 2330 steel: is used extensively for aircraft parts, such as:
bolts, terminals, keys, clevises, and pins.

3, CHROMIUM STEEL :

Chromium steel is:
1, high in hardness
2, high in strength
3, corrosion resistant properties
4, particularly adaptable for heat treated forgings which require greater toughness and strength

may be obtained in plain carbon steel.

can be used for such articles as the:

balls and rollers of anti-friction bearings.

4, STAINLESS STEEL: Chrome nickel or stainless steels
are the corrosion resistant metals.

anti-corrosive degree of this steel is determined by:
1, the surface condition of the metal
2, composition,
3, temperature
4, quantity of the corrosive agent.

The principal alloy of stainless steel is chromium

The corrosion resistant steel most often used in aircraft construction is known as 18-8 steel because of its content of:
1, 18 percent chromium
2, 8 percent nickel

One of the distinctive features of 18-8 steel is:
that its strength may be increased by cold working

Stainless steel may be rolled, drawn, bent, or formed to any shape
Because these steels expand about 50 percent
and conduct heat only about 40 percent
rapidly, they are more difficult to weld.

Stainless steel can be used for almost any part of an aircraft
common applications are in the:
1, fabrication of exhaust collectors
2, stacks and manifolds
3, structural and machined parts
4, stacks and manifolds
5, springs
6, castings
7, tie rods
8, control cables and firewalls

CHROME-VANADIUM STEEL:

made of approximately 18 percent vanadium
1 percent chromium

When heat treated:

1, have strength
2, toughness
3, resistance wear and fatigue

special grade of this steel in sheet form can be cold formed into intricate shapes Deffecault shape

It can be:

1, folded
2, flattened without signs of breaking or failure.

SAE 6150 used for making:

1, springs
2, chrome-vanadium with high carbon content

SAE 6195 used for

1, ball and roller bearings

CHROMOLY STEEL:

Molybdenum small percentages is used in combination with chromium to form chrome-molybdenum steel

Molybdenum is a strong alloying element:
1, raises the ultimate strength of steel without affecting ductility or workability
2, Molybdenum steels are tough and wear resistant,
3, harden throughout when heat treated
4, adaptable for welding

This type steel has practically replaced carbon steel in the fabrication of :
1,fuselage tubing
2, engine mounts
3, other structural parts.

heat-treated SAE X4130 tube is approximately four times as strong as an SAE 1025 tube of the same weight and size.

chrome-molybdenum steel most used in aircraft construction is that series containing 0.25 to 0.55 percent carbon, 0.15 to 0.25 percent molybdenum, and 0.50 to 1.10 percent chromium:

1) These steels, when suitably heat treated, are deep hardening,
2) easily machined,
3) readily welded by either gas or electric methods,
4) adapted to high temperature service.

M: harden throughout when heat treated.

INCONEL:

Inconel is a nickel-chromium-iron alloy
(closely resembling stainless steel) Corrosion Resistant Steel (CRES)
the two alloys look very much alike,
test is often necessary
One method of identification is to use an electrochemical technique

Nickel (Ni) content of the alloy. Inconel has a nickel content greater than 50 percent, and the electrochemical test detects nickel

Aircraft exhaust systems use both alloys interchangeably.

The tensile strength of Inconel is 100 000 psi annealed,
and 125 000 psi when hard rolled.

INCONEL:

is highly resistant to salt water
It's able to withstand temperatures as high as 870°C (1 600°F).

Inconel welds readily and has working qual ities quite similar to those of corrosion resistant steels

SUBSTITUTION OF AIRCRAFT METALS M

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In selecting substitute metals for the repair and maintenance of aircraft;:
check the appropriate structural repair manual

1

The first and most important of these is maintaining the original strength of the structure

other three are:
1,) maintaining contour or aerodynamic 2
2,) maintaining original weight, if possible, or keeping added weight to a minimum 3
3,) maintaining the original corrosion resistant properties of the metal

4

METAL WORKING PROCESSES

three methods of metalworking:
(1) hot working
(2) cold working
(3) extruding

No Need For Percenteg

HOT WORKING

When an ingot is stripped from its mold, its surface is solid, but the interior is still molten.

The ingot is then placed in a soaking pit which retards loss of heat, and the molten interior gradually solidifies

After soaking, the temperature is equalized throughout the ingot

then it is reduced to intermediate size by rolling making it more readily handled

The rolled shape is called a bloom

bloom:
when its section dimensions are 6 inches by 6 inches or larger and approximately square.

billet:
The section is called a billet when it is approximately square and less than 6 inches by 6 inches.

slabs:
Rectangular sections which have a width greater than twice their thickness are called slabs. M
The slab is the intermediate shape from which sheets are rolled

Blooms, billets, or slabs are heated above the critical range and rolled into a variety of shapes of uniform cross section. Common rolled shapes are:

sheet, bar, channel, angle, and I-beam.

hot rolled material is frequently finished by cold rolling or drawing to obtain accurate finish dimensions and a bright, smooth surface.

Complicated sections which cannot be rolled, or sections of which only a small quantity is required, are usually forged.

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Forging:

Forging of steel is a mechanical working at temperatures above the critical range to shape the metal as desired

Forging:

1 2

Forging is done either by pressing or hammering the heated steel until the desired shape is obtained.

Pressing in forging

Pressing is used when the parts to be forged are large and heavy; this process also replaces hammering where high grade steel is required

Since a press is slow acting:
force is uniformly transmitted to the center of the section

Hammering:
1, used only on relatively small pieces

2, its effect is limited to a small depth.

3, it is necessary to use a very heavy hammer or to subject the part to repeated blows to ensure complete working of the section.

If the force applied is too weak to reach the center, the finished forged surface will be concave

- If the center was properly worked, the surface will be convex or bulged

M: hammering where high-grade steel is required

The advantage of hammering:

1, the operator has control over both the amount of pressure applied and the finishing temperature

2, able to produce small parts of the highest grade.

M

smith forging

Smith forging is used extensively where only a small number of parts are needed

Considerable machining time and material are saved when a part is smith forged to approximately the finished shape.

three factors which determine the requirements to be met by any material used in airframe construction and repair

1, Strength

2, weight,

3, reliability

Airframes must be strong and yet as light weight as possible!

increases in strength can be accompanied by increases in weight

The material must possess the strength required by the dimensions, weight, and use;

The five basic stresses which metals may be required to withstand are

1, tension

2, compression

3, shear

4, bending

5, torsion

Tensile strength:

Tensile strength of a material is its resistance to a force which tends to pull it apart

Tensile strength is measured in (psi)

calculated by :

dividing the load in pounds required to pull the material apart by its cross-sectional area in square inches

compression strength

Compression strength of a material is its resistance to a crushing force which is the opposite of tensile strength.

measured in psi

shear

Shear is the tendency on the part of parallel members to slide in opposite directions

Ex: When a piece of metal is cut, the material is subjected, as it comes in contact with the cutting edge, to a force known as shear

The shear strength is the shear force in psi at which a material fails.

the load divided by the shear area.

Bending

Bending can be described as the deflection or curving of a member due to forces acting upon it

The bending strength of material is the resistance it offers to deflecting forces.

Torsion

Torsion is a twisting force

Such action would occur in a member fixed at one end and twisted at the other.

torsional strength of material is its resistance to twisting.

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the strength/weight ratio

The relationship between the strength of a material and its weight expressed as a ratio. M

Corrosion

Corrosion is the eating away or pitting of the surface or the internal structure of metals

would be dangerous to select a material possessing poor corrosion resistant characteristics

M

Fatigue

occurs in materials which are exposed to frequent reversals of loading or repeatedly applied loads. Repeated vibration or bending will ultimately cause a minute crack to occur at the weakest point.

As vibration or bending continues, the crack lengthens until the part completely fails

Resistance to this condition is known as shock and fatigue resistance

is essential that materials be resistant to these stresses

The hardening of metals by cold working or forming is termed work hardening. If a piece of metal is formed (shaped or bent) while cold, it is said to be cold worked.

Practically all the work an aviation mechanic does on metal is cold work metal to become harder and more brittle.

If the metal is cold worked too much, that is, if it is bent back and forth or hammered at the same place too often, it will crack or break

more malleable and ductile a metal is, the more cold working it can stand.

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Any process which involves controlled heating and cooling of metals to develop certain desirable characteristics such as:
hardness,
softness, ductility,
tensile strength,
or refined grain structure
is called heat treatment or heat treating

With steels the term "heat treating" has a broad meaning and includes such processes as:

annealing

normalizing

hardening

tempering

All of these processes Will be explained one by one

M

HEAT TREATING

Heat treatment is:

1, Heat treatment is a series of operations involving the heating and cooling of metals in the solid state

2, a Treatment given to the materials to get the needed properties

By heat treating, a metal can be made:

1, harder
2, stronger
3, more resistant to impact

Heat treating can also make a metal:

1, softer
2, more ductile

No one heat treating operation can produce all of these characteristics some properties are often improved at the expense of others

Ex: In being hardened, metal may become brittle

The most common forms of heat treatment for ferrous metals are:

1,hardening
2, tempering
3, normalizing
4, annealing
5, case hardening.

M: however

Internal Structure of Metals:M

1

The results obtained by heat treatment depend to a great extent on the structure of the metal

2

pure metal cannot be hardened by heat treatment because there is little change in its structure when heated.

M

3

On the other hand, most alloys respond to heat treatment since their structures change with heating and cooling. An alloy may be in the form of a solid solution, a mechanical mixture, or a combination of a solid solution and a mechanical mixture. When an alloy is in the form of a solid solution, the elements and compounds which form the alloy are absorbed, one into the other, in much the same way that salt is dissolved in a glass of water, and the constituents cannot be identified even under a microscope alloy in the form of a mechanical mixture at ordinary temperatures may change to a solid solution when heated When cooled back to normal temperature the alloy may return to its original structure

On the other hand, it may remain a solid solution or form a combination of a solid solution and mechanical mixture

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An alloy which consists of a combination of solid solution and mechanical mixture at normal temperatures may change to a solid solution when heated

When cooled, the alloy may remain a solid solution, return to its original structure, or form a complex solution.

Heat Treating Equipment

Successful heat treating requires close control over all factors aff cting the heating and cooling of metals

1, the furnace.

A) the furnace must be of the proper size and type and must be so controlled that temperatures are kept within the limits prescribed for each operation.

B) Even the atmosphere within the furnace affects the condition of the part being heat treated

2, the quenching equipment

A) the quenching equipment and the quenching medium must be selected to fit the metal and the heat treating operation.

A1, sand

A2, water

A3, oil.

A4, brine

C) the handling equipment

for :

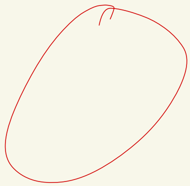
C1, cleaning metals.

C2, straightening parts.

C3, quenching tank

C4, circulating pumps and coolers

Point C4 is used for: to maintain approximately constant temperatures when doing a large amount of quenching.



FURNACES

FURNACES

many different types and sizes of furnaces used in heat treatment

general rule
furnaces are designed to operate in certain specific temperature range

attempted use in other ranges frequently results in work of inferior quality. (bad quality)

Types of furnaces

1, Fuel fired furnaces (gas or oil)

A) require air for proper combustion and an air compressor or blower

B) These furnaces are usually of the muffler type
Meaning:
the combustion of the fuel takes place outside of and around the chamber in which the work is placed

C) If an open muffler is used, the furnace should be designed to prevent the direct impingement of flame on the work

2, furnaces heated by electricity

A) the heating elements are generally in the form of wire or ribbon

B) different furnaces give different heat

C) Such furnaces commonly operate at up to a maximum temperature of about 1 100°C.

D) Furnaces operating at temperatures up to about 1 400°C usually employ resistor bars of sintered carbides.

Temperature Measurement and Control (furnace)

Temperature in the heat-treating furnace is measured by a thermoelectric instrument known as a : pyrometer Mi,I,iii

Different type of furnaces have different thermoelectric instruments

pyrometer:
1, is a instrument measures the electrical effect of a thermocouple and, hence, the temperature of the metal being treated.

A complete pyrometer consists of three parts
1, a thermocouple
2, extension leads
3, meter

M
Pyrometers may have meters either of the indicating type or recording type:
ndicating pyrometers: give direct reading of the furnace temperature.

Recording type produces a permanent record of the temperature range throughout the heating operation by means of an inked stylus attached to an arm which traces a line on a sheet of calibrated paper or temperature chart

- Pyrometer installations on all modern furnaces provide automatic regulation of the temperature at any desired setting.

If temperature measuring equipment is not available

An inexpensive, yet fairly accurate method involves the use of:method 1:
1, commercial crayons
2, pellets
3, paints that melt at various temperatures within the range of 50°C to 870°C.

The least accurate method: method 2:
observation of the color of the hot hearth of the furnace or of the work.

atmosphere control:

Commercial furnaces, are generally equipped with some means of
atmosphere control.
This usually is in the form of a burner for burning controlled amounts of gas
and air and directing the products of combustion into the furnace muffle.

And protecting the steel from:
1, surface oxidation (scaling)
2, loss of carbon from the surface layers (decarburization)

Water vapor, a product of this combustion, is detrimental and many furnaces are equipped with a means for eliminating it

For furnaces not equipped with atmosphere control:
atmosphere generators are available.

Atmosphere generators:
1, achieving a successful process is control of the atmosphere.
2, commonly used in industrial furnaces and heat treating.

If no method of atmosphere control is available degree of protection may be secured by covering the work with :
A) cast iron borings or chips.

Vacuum furnaces

used for annealing steels

especially when a bright non-oxidized surface is a prime consideration.

tempering furnace

Furnaces intended primarily for tempering may be heated by gas or electricity and are frequently equipped with a fan for circulating the hot air.

Heat treating furnaces different in:
1, size
2, shape
3, capacity
4, construction
5, operation
6, control

Heat treating furnaces may be:
1, circular
2, rectangular

Heat treating furnaces may rest on:
1, pedestals
2, directly on the floor
3, pit type furnaces, which are below the surface of the floor

The size and capacity of a heat treating furnace:

depends on the intended use.
furnace must be capable of heating rapidly and uniformly.

An oven type furnace :
should have a working space (hearth) about twice as long and three times as wide as any part that will be heated in the furnace.

Salt baths

Salt baths are available for operating at either tempering or hardening temperatures

Salt baths: is a quenching process
1, some time inside the furnace
1.1) meaning: butting nitrate salt in a container and the material that will be heat treated in the same container inside the furnace

2, quenching
2.1) after getting the material out of the furnace the material will be quenched in the salt bath

Temperature Measurement and Control:

salt bath, heating can be conducted at temperatures:
low as 165°C to as high as 1 350°C.

Lead baths

Have the same process as the salt bath
can be used in the temperature range of 345°C to 925°C

work in salt or lead baths is surrounded by the liquid heating medium, the problem ofpreventing scaling or decarburization is simplified.

Accurate temperature measurement is essential to good heat treating.

The usual method is by means of thermocouples:

the most common base metal couples are:
1, copper-constantan (up to 370°C)
2, iron-constantan (up to about 760°C)
3, chromel-alumel (up to 1 200°C).

The most common noble metal couples (which can be used up to about 1 550°C) are:
1, platinum coupled with either the alloy 87 percent platinum (13 percent rhodium)
Or
2, the alloy 90 percent platinum (10 percent rhodium).

HEATING

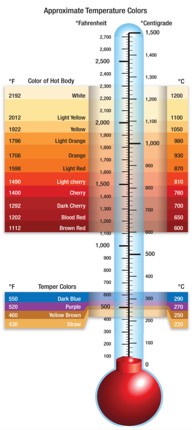
The object in heating is to transform :

pearlite To austenite

relatively slow rate of heating must be used

steel is inserted when the temperature in the furnace is :
from 150°C to 260°C below the hardening temperature.

rapid heating through the critical range is prevented



SOAKING

The temperature of the furnace must be held constant during the soaking period because:
during this period that rearrangement of the internal structure of the steel takes place.

Soaking temperatures
for various types of steel are specified in ranges varying as much as 40°C.
1, Small parts are soaked in the lower part of the specified range
2, heavy parts in the upper part of the specified range.

soaking period
depends upon the type of steel and the size of the part

heavier parts require longer soaking to ensure equal heating throughout

soaking period of 30 minutes to 1 hour is sufficient for the average heat-treating operation.

COOLING

cooling through the critical range determines the form that the steel will retain.

COOLING types

1, Still air
2, furnace cooling
3, Liquids (brine, water, oil)

1, still air

A) Still air is a slow cooling medium, but is much faster than furnace cooling.
B) letting the material to cool in the air

2, furnace cooling

A) letting the material to cool in the furnace

3, Liquids

A) Liquids are the fastest cooling media and are therefore used in hardening steels

B.1) Brine is the strongest quenching medium
B.2) water is next
B.3) and oil is the least.

C.1) oil quench is used for alloy steels
C.2) and brine or water for carbon steels

Quenching solutions act only through their ability to cool the steel.

Most requirements for quenching media are met satisfactorily by water or aqueous solutions of inorganic salts, such as table salt or caustic soda, or by some type of oil brine

The rate of cooling is relatively rapid during quenching in brine

Brine usually is made of :

5 to 10 percent solution of salt (sodium chloride) in water

brine has the ability to:

"throw" the scale from steel during quenching

The cooling ability of both water and brine, particularly water, is affected by their temperature

Both should be kept cold—well below 15°C.

If the volume of steel being quenched tends to raise the temperature of the bath appreciably:

add ice or use some means of refrigeration to cool the quenching bath.

(don't let the liquid to become hot)

quenching oils (memorizing is optional)

their cooling rates do not vary widely : ex (there is no much difference between quenching oils most have the same quenching properties)

straight mineral oil with a Saybolt viscosity of about 100 at 38°C is generally used.

oils have the greatest cooling velocity at a slightly elevated temperature—about 38 to 60°C—because: their decreased viscosity at these temperatures

Just read

When steel is quenched, the liquid in immediate contact with the hot surface vaporizes; this vapor reduces the rate of heat abstraction markedly. Vigorous agitation of the steel or the use of a pressure spray quench is necessary to dislodge these vapor films and thus permit the desired rate of cooling. The tendency of steel to warp and crack during the quenching process is difficult to overcome because certain parts of the article cool more rapidly than others. The following recommendations will greatly reduce the warping tendency: 1. Never throw a part into the quenching bath. By permitting it to lie on the bottom of the bath, it is apt to cool faster on the top side than on the bottom side, thus causing it to warp or crack.

2. Agitate the part slightly to destroy the coating of vapor that could prevent it from cooling evenly and rapidly. This allows the bath to dissipate its heat to the atmosphere.

3. Immerse irregular shaped parts so that the heavy end enters the bath first.

HEAT TREATMENT OF FERROUS METALS

first important consideration in the heat treatment of a steel part is to know its chemical composition (high carbon or low carbon)

This determines its: upper critical point and lower critical point
Ex:
Each metal have a lower critical point and upper critical point
Low critical points: paralite structure starts to change to austenaite
Upper critical point: if heat is applied more the material will melt

When the upper critical point is known:
the next consideration is the rate of heating and cooling to be used
1, use of uniform heating furnaces
2, proper temperature control
3, suitable quenching mediums

With steels the term "heat treating" has a broad meaning and includes such processes as:
annealing
normalizing
hardening
tempering

HARDENING

Pure iron, wrought iron, and extremely low carbon steels cannot be appreciably hardened by heat treatment because: they contain no hardening element.

Cast iron can be hardened, but its heat treatment is limited:
cooled rapidly, it forms white iron, which is hard and brittle.
cooled slowly, it forms gray iron, which is soft but brittle under impact.

the maximum hardness :
depends almost entirely on the carbon content of the steel

As the carbon content increases, the ability of the steel to be hardened increases.
However, this increase in the ability to harden with an increase in carbon content continues only to a certain point:

1, that point is 0.85 percent carbon content.
2, When the carbon content is increased beyond 0.85 percent, there is no increase in wear resistance.

the hardening treatment consists of :
1, heating the steel to a temperature just above the upper critical point
2, soaking or holding for the required length of time
3, then cooling it rapidly by plunging the hot steel into oil, water, or brine

Although most steels must be cooled rapidly for hardening a few may be cooled in still air.

Hardening increases the hardness and strength of the steel but makes it less ductile. (hardness increases ductility decreases)

hardening carbon steel
it must be cooled to below 540°C in less than 1 second

If not cooled in 1 second:
the austenite begins to transform into fine pearlite

This pearlite varies in hardness, but is much harder than the pearlite formed by annealing and much softer than the martensite desired.

After the 540°C temperature is reached, the rapid cooling must continue if the final structure is to be all martensite

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TEMPERING

Tempering is given after the hardening

Tempering is always conducted at temperatures below the low critical point of the steel.

Tempering reduces the brittleness

Tempering process
1, tempering begins at 100°C and continues as the temperature increases toward the low critical point.
2, resulting hardness and strength can be predetermined.
3, the heat of the furnace should be exact.
4, cooled in still air

Time of tempering
1, The minimum time at the tempering temperature should be 1 hour
2, If the part is over 1 inch in thickness, increase the time by 1 hour for each additional inch of thickness

Tempered steels used in aircraft work have a tensile strength from:
125 000 to 200 000 psi

ANNEALING

6

Annealing of steel produces a
1, fine grained
2, soft
3, ductile metal
4, without internal stresses or strains

In the annealed state: steel has its lowest strength.

annealing is the opposite of hardening.

Annealing process:
1, heating the metal to just above the upper critical point,
2, soaking at that temperature
3, cooling very slowly in the furnace

Soaking time:
1, approximately 1 hour
2, per inch of thickness of the material.

For maximum softness:
the metal must be cooled very slowly

Slow cooling is obtained by :
1, shutting offthe heat
2, allowing the furnace and metal to cool together to 480°C or lower
3, then removing the metal from the furnace and cooling in still air

Another slow cooling method:
1, bury the heated steel in ashes, sand, or other substance that does not conduct heat readily

Know them

NORMALIZING

normalizing removes the internal stresses set up by:
1, heat treating
2, welding
3, casting
4, forming
5, machining

If stress not controlled, will lead to failure of the material

aircraft steels are often used in the normalized state

One of the most important uses of normalizing in aircraft work is in welded parts

Process of normalizing:
heating the steel above the upper critical point and cooling in still air

The more rapid quenching obtained by air cooling is better than furnace cooling:
Rapid cooling gives harder and stronger material than that obtained by annealing

6

CASE HARDENING

Case hardening produces a:

produces a hard wear resistant surface or case over a strong, tough core

Case hardening is ideal for

1, parts which require a wear resistant surface

2, at the same time, must be tough enough internally to withstand the applied loads

The steels best suited to case hardening are:

the low carbon and low alloy steels

high carbon steel is case hardened:

the hardness penetrates the core and causes brittleness

What dose case hardening do:

the surface of the metal is changed chemically by introducing a high carbide or nitride content

The core is unaffected chemically.

When heat treated, the surface responds to hardening while the core toughens

The common forms of case hardening are :

1, carburizing (adding carbon)

2, cyaniding (not used in aircraft)

3, nitriding (adding nitride)

Each one of these common forms will be explained in detail

Carburizing

Carburizing is a case hardening process
which carbon is added to the surface of low carbon steel

When the carburized steel is heat treated:
the case is hardened while the core remains soft and tough

common method of carburizing

1, pack carburizing:

carburizing is to be done by this method, the steel parts are packed in a container with charcoal or some other material rich in carbon. The container is then sealed with fire clay, placed in a furnace, heated to approximately 925°C, and soaked at that temperature for several hours

2, gas carburizing:

Another method ofcarburizing is called "gas carburizing," a material rich in carbon is introduced into the furnace atmosphere. The carburizing atmosphere is produced by the use of various gases or by the burning of oil, wood, or other materials. When the steel parts are heated in this atmosphere, carbon monoxide combines with the gamma iron to produce practically the same results as those described under the pack carburizing process.

3, liquid carburizing

In this method, the steel is placed in a molten salt bath that contains the chemicals required to produce a case comparable with one resulting from pack or gas carburizing.

Nitriding

Nitriding process:

1, nitriding, the part is placed in a special nitriding furnace
2, heated to a temperature of approximately 540°C.
3, With the part at this temperature, ammonia gas is circulated within the specially constructed furnace chamber.
4, The high temperature cracks the ammonia gas into nitrogen and hydrogen.
5, The ammonia which does not break down is caught in a water trap below the regions of the other two gases.
6,The nitrogen reacts with the iron to form nitride.
7, The iron nitride is dispersed in minute particles at the surface and works inward.

The depth of penetration depends on the length of the treatment.

Soaking periods : 72 hours are frequently required to produce the desired thickness of case

FORGING

Forging is the process offorming a product by hammering or pressing.

When the material is forged below the recrystallization temperature:
it is called cold forged

When worked above the recrystallization temperature:
it is referred to as hot forged

Drop forging : know the process just understand
1, is a hammering process
2, uses a hot ingot that is placed between a pair of formed dies in a machine called a drop hammer and a weight of several tons is dropped on the upper die

This results in the hot metal being forced to take the form of the dies.

Because the process is very rapid, the grain structure of the metal is altered, resulting in a significant increase in the strength of the finished part.

CASTING

Casting process:
melting the metal and pouring it into a mold of the desired shape

Castings are
normally lower in strength
more brittle than a wrought product of the same material
(not primarily used in structural parts)

For Complicated parts :
casting may be the most economical process ex: turbine blades

Except for engine parts, most metal components found on an aircraft are wrought instead of cast.

Both iron and aluminum alloys are cast for aircraft uses. All metal products start in the form of casting

EXTRUDING

750 - 850

Extruding process:

1, extrusion process involves the forcing of metal through an opening in a die

2, causing the metal to take the shape of the die opening.

3, The shape of the die will be the cross section of an angle, channel, tube, or some other shape.

Some metals such as
1,lead
2, tin
3, and aluminum
may be extruded cold

not heated

most metals are heated before extrusion.

The main advantage of the extrusion process is its : flexibility

Just read

Extruded shapes are produced in very simple as well as extremely complex sections. In this process a cylinder of aluminum, for instance, is heated to 400–455°C and is then forced through the opening of a die by a hydraulic ram. The opening is the shape desired for the cross section of the finished extrusion. Many structural parts, such as channels, angles, T-sections, and Z-sections, are formed by the extrusion process.

Aluminum is the most extruded metal used in aircraft. Aluminum is extruded at a temperature of 371–482°C and requires pressure of up to 80 000 psi (552 MPa). After extrusion, the product frequently will be subjected to both thermal and mechanical processes to obtain the desired properties. Extrusion processes are limited to the more ductile materials.

COLD WORKING
/
HARDENING

Cold working applies to mechanical working performed at temperatures below the critical range

results in a strain hardening of the metal

Cold working increased:
1, strength
2, hardness
3, elastic limit

Cold work decrease:
1, ductility

this makes the metal more brittle, it must be :
1, heated from time to time during certain operations
2, to remove the undesirable eff cts of the working.

cold working processes used in aviation mechanic:
1, cold rolling
2, cold drawing

Cold rolling usually working of metal at room temperature

In this operation:
materials that have been rolled to approximate sizes are pickled to remove the scale, after which they are passed through chilled finishing rolls

This gives:
1, smooth surface
2, brings the pieces to accurate dimensions

The principal forms of cold rolled stocks are:
1, sheets
2, bars
3, rods

Cold drawing

used in making:

1, seamless tubing
2, wire
3, streamlined tie rods
4, and other forms of stock

1, dipped in lime water
2, then dried in a steam room where they remain until ready for drawing.

The lime coating adhering to the metal serves as a lubricant during the drawing operation.

HARDNESS TESTING

HARDNESS TESTING

Hardness testing is a method of determining the :

1, results of heat treatment

2, the state of a metal prior to heat treatment.

hardness tests are a valuable check of

1, heat-treat control

2, material properties

Practically all hardness testing equipment now uses the resistance to penetration as a measure of hardness

hardness testers

1, BRINELL TESTER

2, ROCKWELL TESTER

3, TENSILE STRENGTH TESTING

4, FATIGUE STRENGTH TESTING

5, IMPACT TESTING

6, ELECTROCHEMICAL TESTING OF STAINLESS VS INCONEL

Know the type

BRINELL TESTER

The Brinell hardness tester uses a
1, hardened spherical ball
2, which is forced into the surface of the metal.

This ball is :
10 millimeters (0.393 7 inch) in diameter.

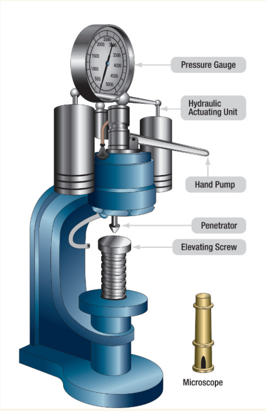
pressure of :
1, 3 000 kilograms is used for ferrous metals
2, 500 kilograms for nonferrous metals

The pressure must be maintained at least 10 seconds for ferrous metals

The pressure must be maintained at least 30 seconds for nonferrous

The load:
1, load is applied by hydraulic pressure
2, built up by a hand pump or an electric motor
3, depending on the model of tester

after the test has been made:
calibrated microscope is provided for :
measuring the diameter of the impression in millimeters



To determine the Brinell hardness number for a metal
1, measure the diameter of the impression, using the calibrated microscope furnished with the tester

2, convert the measurement into the Brinell hardness number on the conversion table furnished with the tester

ROCKWELL TESTER

measures the resistance to penetration, as does the Brinell tester

the Rockwell tester measures the
1, depth, and the hardness is indicated directly on a dial attached to the machine
(no calculations is needed)

The dial numbers in the outer circle are black
the inner numbers are red

Rockwell hardness numbers are based on the difference between the depth of penetration at:
1, major
2, minor loads

The greater this difference:
the lower the hardness number and the softer the material.

Two types of penetrators are used with the Rockwell tester:
1, a diamond cone
2, hardened steel ball

The load which forces the penetrator into the metal is called the:
major load and is measured in kilograms

The results of each penetrator and load combination are reported on separate scales, designated by letters.

The penetrator, the major load, and the scale vary with the kind of metal being tested. Meaning (different materials have different values)

For hardened steels, the diamond penetrator is used;
1, the major load is 150 kilograms; and the hardness is read on the "C" scale.
2, When this reading is recorded, the letter "C" must precede the number indicated by the pointer.

Th C-scale setup is used for testing metals:
ranging in hardness from C-20 to the hardest steel (usually about C-70).

If the metal is softer than C-20:
the B-scale setup is used.

With this setup:
1, /16-inch ball is used as a penetrator
2, the major load is 100 kilograms
3, the hardness is read on the B-scale.

The Rockwell tester is equipped with:
1, weight pan
2, two weights are supplied with the machine
3, One weight is marked in red. The other weight is marked in black

With no weight in the weight pan, the machine applies a major load of 60 kilograms

If the scale setup calls for a 100 kilogram load:
the red weight is placed in the pan

For a 150 kilogram load:
the black weight is added to the red weight.

the colors may be used as a guide in selecting the weight (or weights) and in reading the dial

The black weight is always used with the red weight; it is never used alone.

the diamond penetrator for testing materials known to be hard.

If the hardness is unknown:

1, try the diamond

2, since the steel ball may be deformed if used for testing hard materials

3, If the metal tests below C-22, then change to the steel ball.

Use the steel ball for all soft materials:

those testing less than B-100.

Before the major load is applied, securely lock the test specimen in place to prevent :

1, slipping

2, and to seat the anvil and penetrator properly

The minor load is 10 kilograms regardless of the scale setup.

The metal to be tested in the Rockwell tester must be

1, ground smooth on two opposite sides

2, free of scratches and foreign matter

3, The surface should be perpendicular to the axis of penetration

4, the two opposite ground surfaces should be parallel

error will occur if:

1, If the specimen is tapered,

2, curved surface will also cause a slight error in the hardness test.

the smaller the radius of curvature, the greater the error

To eliminate such error:

a small flat should be ground on the curved surface if possible

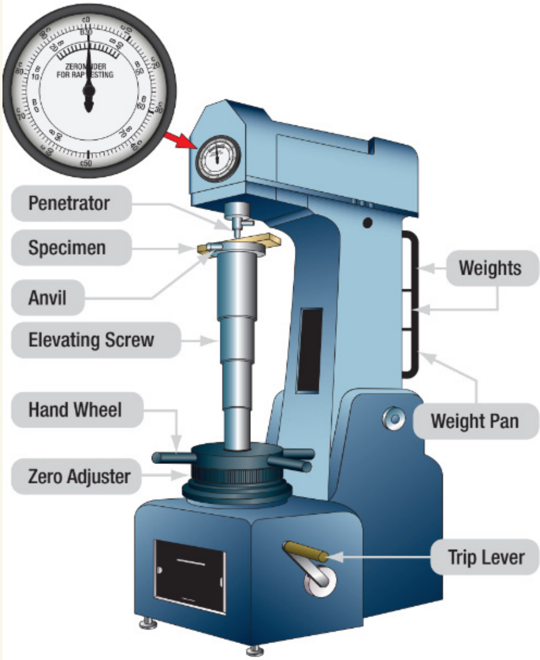


Figure 1-5. Rockwell hardness tester.

Scale Symbol	Penetrator	Major Load (kg)	Dial Color/Number
A	Diamond	60	Black
B	1/16-inch ball	100	Red
C	Diamond	150	Black
D	Diamond	100	Black
E	1/8-inch ball	100	Red
F	1/16-inch ball	60	Red
G	1/16-inch ball	150	Red
H	1/8-inch ball	60	Red
K	1/8-inch ball	150	Red

Figure 1-6. Standard Rockwell hardness scales.

TENSILE STRENGTH TESTING

The tensile strength of a material is what is commonly thought of as the strength of a material

It is a measurement of tension, which is the stress that resists a force that tends to pull a material apart

To perform a test of tensile strength

1, the material is secured in a:

1.1, designed electromagnetically or

1.2, hydraulically powered machine

that exerts force on the material to pull it apart.

2, While the force is applied and increased, dimensional measurements are made and recorded.

A tensile strength test could be performed by

1, clamping a sample of the material securely

2, then hanging weight from it until it fails.

that tensile strength is a weight-related measurement

weight per unit area is used. psi

FATIGUE STRENGTH TESTING:

Fatigue is a weakness in materials, especially metals, caused by repeated variation s of stress.

Metal fatigue can cause micro cracks and other fatigue damage precursors that are sought during periodic inspection.

to detect metal fatigue use
1, Visual
2, , eddy current
3, ultra sound
4, fluorescent penetrant
5, magnetic particle
6, radiography inspection techniques are all employed in various situation

The progression from a micro crack to cracks that join to cause a large section of metal to fail can be rapid.(the first sign that a metal will fail)

New studies and method of detection are being developed such as
1, electrochemical
2, light scattering inspection processes.

IMPACT TESTING

Impact tests are used to indicate:
1, the toughness of a material
2, its ability to resist mechanical shock, to ensure that temper brittleness has not been introduced during heat treatments.

Toughness is broadly a measure of
1, the amount of energy required to cause an item
2, a test piece or a bridge or a pressure vessel
to fracture and fail.

The more energy that is required then the tougher the material

There are two types of machine used for testing aircraft materials, both of which use a pendulum weight to fracture the specimen.
(Dropping the pendulum on the material that is being tested)

The energy absorbed by the specimen is measured from the angle through which the pendulum swings after causing the fracture.

The IZOD test is required by most of the British material specifications, but where the test piece must be tested at high or low temperatures the CHARPY test is used.

The test is carried out within the 6 seconds of removal of the test piece from the heating or cooling bath. Machines are available which carry out both the Izod and Charpy tests.

Final
Quetion

Figure 1-8. An IZOD impact test machine.