Workshop : Tutorial Sheet :

- Properties And testing Of Metals.

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Physical properties of Metals :

The physical properties of metals can be summed up as follows :-

① Because they contain free-moving electrons, metals are good electrical conductors, allowing electricity to flow through them. Because metal is a good conductor of electricity, copper is utilised for wiring.

② Due to their solid metallic connections, metals have high melting and boiling points.

③ Physically, all metals are shiny. They shine because of a sheen they possess. Jewellery is produced with gold.

④ Metals are tough, difficult to shatter and demand a lot of strength and energy. Cars structures, ships & other items are made of iron.

⑤ Metals are heavy because of their great density for their size, metals are hefty.

③ Metals are efficient heat and electrical Conductors. The one exception is lead.

④ At normal temperatures, metal often exit in a Solid State. Excluding Mercury. Mercury is liquid at this temperature.

⑤ Metals like gold, Silver, platinum and other less reactive metals don't tarnish as quickly. They Continue to shine & glisten.

⑥ When metals and water interact, metal oxide and hydrogen gas are produced.
~~for~~ example —

$$Na + H_2O \Longrightarrow NaOH + H_2$$

$$K + H_2O \Rightarrow KOH + H_2$$

$$Ca + 2H_2O \Rightarrow Ca(OH)_2 + H_2$$

$$Mg + 2H_2O \Rightarrow Mg(OH)_2 + H_2$$

(7) Oil is used to hold metals like Salt and potassium, which quickly react with air. They are metals with strong reactivity.

(8) Some metals don't reach with water. However, when highly reactive metals like Sodium and potassium combine with water, a strong reaction occurs and an exothermic reaction occurs igniting the hydrogen.

Testing of Metals

Metal testing is the process or procedure to check composition of an unknown metallic substance. There are destructive process and Non-distructive processes. Metal testing can also include, determining the properties of newly forged metal alloys.

The original sample in complete re-usable condition. This type of testing is non-destructive When working with alloys (forged mixture) of metals however, to determine the exact composition could result in the original sample being separated.

into its Starting materials, then measured and Calculated. After the Components are known they can be looked up and matched to known alloys. The original Sample would be destroyed in this process. This type of testing is destructive.

Destructive Testing (DT)

In this testing, the material Undergoes Mechanical testing & is discarded thereafter. Test results are Compared with Specifications. Subtypes include.

(i) Aggressive environment testing.
(ii) Corrosion testing.
(iii) Fracture and mechanical testing
(iv) Fatigue testing
(v) Hardness testing
(vi) Hydrogen testing
(vii) Residual Stress measurement
(viii) Software testing
(ix) Tensile (elongation) testing
(x) Torsion testing.

(i) Aggressive Environment testing :

Aggressive environment testing is used to test fatigue & fracture points of a Component when it is exposed to Corrosive environments at different pressure and temperatures.

Examples of Corrosive environments include those that Contain :

-> Salinity
-> Humidity
-> Hydrogen Sulfide
-> Carbon dioxide
-> And other natural elements.

(ii) Corrosion testing :

Corrosion testing tests a Component's Corrosion point when it is exposed to Salt water and freshwater.

(iii) Fracture and Mechanical testing :

Fracture and mechanical testing includes the following destructive tests :

- Bend test is a quality Control test that bends materials either in a guided or free from test to expose embrittlement.
- Charpy impact test is a high Strain DT method that determines the amount of energy absorbed by a material during a fracture.
- Crush test or Compressive Strength test is a very test widely used to determine the Strength of Concrete bearing loads.
- Weld fracture test
- Peel & Chisel test
- Pellini drop weight test.

(iv) Fatigue testing :

Fatigue testing is Conducted in Salt Water or open-air environments to determine the endurance of welded joints, base metals, & heat affected zones under Variable -or Constant-amplitude loading.

(v) Hardness testing :

Hardness testing determines whether a Component Undergoes permanent deformation under Stress using the Rockwell Scale. How much a material resists indentation is what determines hardness. The test determines How well a Component will perform over time and how long it Can be in use.

(vi) Hydrogen testing :

Hydrogen testing exposes a Component at risk of Corrosion to hydrogen at different Strain rates & temperatures.

(vii) Residual Stress Measurement :

Residual Stress measurement measures the internal Stress

of a Component and its effect on the Surface Stress. These measurements allow engineers to analyze residual Stress distribution.
There are three methods that Can be used in residual Stress measurement :

→ Neutron diffraction
→ Synchroton diffraction
→ x-ray diffraction .

(viii) Software testing :

Software testing is performed by Software engineers who investigate the quality of the Softwares, find failures, & understand risks before the product is fit for use .

(ix) Tensile testing :

Tensile testing is a type of Stress testing performed by elongating or Compressing a Component to determine the Strength of the material. Breaking Strength, Maximum elongation & Compression, & Tensile Strength are all measured to Calculate physical properties and to determine which materials Can withstand a great amount of force .

(x) Torsion testing :

Torsion testing is a type of Stress St testing Where twisting forces are applied to determine Shearing of the material before it becomes deformed. once the material succumbs to twisting, that is considered the failure point of the material.

Non-Destructive Testing Me (NDT)

Raw and finished Material Undergoes testing according to Code Specifications Such as ASME Boiler and pressure Vessel. The tested Material is not damaged by the test. Subtypes include-

(i) Electromagnetic testing
(ii) Ground penetrating Radar
(iii) Laser testing methods
(iv) Leak testing
(v) Magnetic flux Leakage
(vi) Microwave testing.
(vii) Liquid penetrant testing
(viii) Magnetic particle testing
(ix) Neutron Radiographic testing
(x) Radiographic testing.

(i) Electromagnetic testing (ET) :

This testing methods uses an electric current or Magnetic field which is passed through a Conductive part. There are three types of electromagnetic testing :

→ Eddy Current testing
→ Alternating Current field Measurement (ACFM)
→ Remote field testing (RFT)

(ii) Ground penetrating Radar (GPR) :

This geophysical NDT Method sends radar pulses through the Surface of a material or Subsurface Structure, such as rock, ice, water or soil. The Waves are reflected or refracted when they encounter a buried object or material boundary with different electromagnetic properties.

(iii) Laser testing methods (LM) :

Laser testing falls into three Categories including holographic testing, laser profilometry and laser Shearography.

→ Holographic testing uses a laser to detect changes in the surface of the material which has been subjected to stress such as heat, pressure or vibration.

→ Laser profilometry uses a high speed rotating laser light source and miniature optics to detect corrosion, pitting, erosion and cracks by detecting changes in the surface via a 3D image generated from the surface topography.

→ Laser shearography uses laser light to create an image before the surface is stressed and a new image is created.

(iv) Leak testing (LT) :

Leak testing can be broken down into four different methods - bubble leak testing, Pressure change testing, halogen diode testing and mass spectrometer testing.

→ Bubble leak testing uses a tank of liquid, or a soap solution for larger parts, to detect gas (usually air) leaking from the test piece in the form of bubbles.

→ Pressure change testing uses either pressure or a vacuum to monitor the test piece.

→ Halogen diode testing also uses pressure to find leaks, except in this case air and a halogen-based tracer gas are mixed together and a halogen diode detection unit is used to locate any leaks.

→ Mass spectrometer testing uses helium or a helium and air mix inside a test chamber with a 'sniffer' to detect any changes in the air sample, which would indicate a leak.

(v) Magnetic flux Leakage (MFL):

This method uses a powerful magnet to create magnetic field which saturate steel structures such as pipelines & storage tanks. A sensor is then used to detect changes in magnetic flux density which show any reduction in material due to pitting, erosion or corrosion.

(vi) Microwave testing:

This method is restricted to use on dielectric materials and uses microwave frequencies transmitted and recieved by a test probe. The test probe detects changes in dielectric properties such as shrinkage cavity, pores, foreign materials or cracks and displays the results as B or C scans.

(vii) Liquid penetrant testing (PT) :

Liquid penetrant testing involves the application of a fluid with low viscosity to the material to be tested. This fluid seeps into any defects such as cracks or porosity before a developer is applied which allows the penetrant liquid to seep upwards and create a visible indication of the flaw.

(viii) Magnetic particle testing (MT) :

This NDT process uses magnetic fields to find discontinuities at or near the surface of ferromagnetic materials. The magnetic field can be created with a permanent magnet or an electromagnet which requires a current to be applied.

(ix) Neutron Radiographic testing (NR) :

Neutron radiography uses a beam of low energy neutrons to penetrate into the workpiece. While the beam is transparent in metallic materials most organic materials allow the beam to be seen, allowing the structural & internal components to be viewed and examined to detect flaws.

(x) Radiographic testing (RT):

Radiographic testing uses radiation passed through a test piece to detect defects. X ray are commonly used for thin or less dense materials while gamma rays are used for thicker or denser items. The result can be processed wat using film radiography, Computed tomography or digical rediography.

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