BUREAU OF INDIAN STANDARDS

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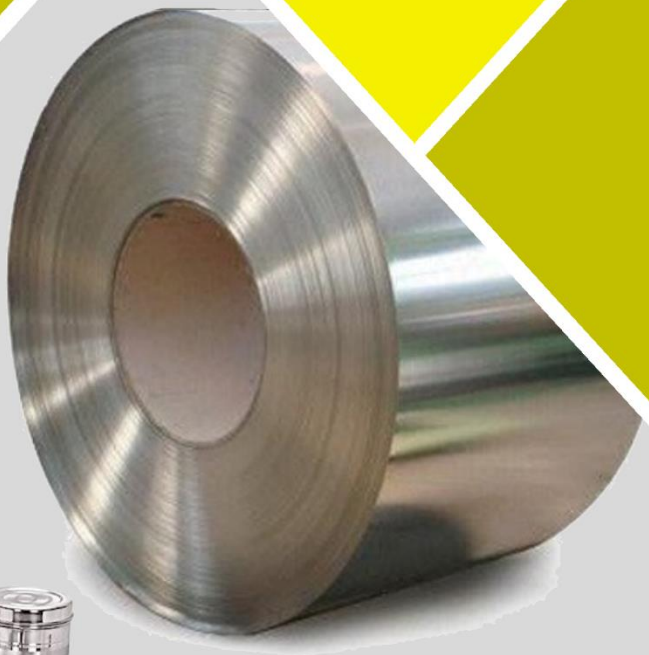
Learning Science via Standards

Stainless Steel



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Lesson 30

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STANDARDS CLUB
BUREAU OF INDIAN STANDARDS

Nurturing Young Minds as Ambassadors of Quality and Standards

Foreword

Everything around us, whether natural phenomena or manmade products can be explained through science. The product which are used in our daily life are outcome of conscious efforts by the mankind to fulfil and exceed the needs of the present and demands of the future. Students are taught science as part of their school curriculum, to enable them to understand the various scientific laws and principles and also to inculcate the habit of exploring the world through the lens of science. Quality characteristics of any product or service are decided based on the stated and implied needs and are generally described in a document called 'Standard'. Science and standards are inseparable and integral aspect of any product.

Bureau of Indian Standards (BIS), the national standards body of India, is mandated for establishment and promotion of standards and creating a quality ecosystem in the country. This is achieved through developing Indian Standards on products and services through the active involvement of relevant stakeholders and dissemination of information of such standards for their use and implementation across all sectors of economy. Academia, as an important stakeholder of BIS, has been contributing towards development of standards through research activities and providing inputs related to technological advancements in product development, their characteristics and use as well as methods of tests. BIS, on its part has also been promoting standards in academia through a variety of programmes. This has since been institutionalized in the form of "Standards Clubs" which are being established in educational institutions across India to nurture the young minds as ambassadors of quality and standards and prepare them for dealing with these aspects in future.

In this initiative of BIS, called "Learning Science via Standards", a series of Lesson Plans are made elaborating the various scientific concepts, laws and principles to help students understand their practical applications via standards. The series comprises of a variety of subjects for insights into the scientific laws and principles and relating them to the quality characteristics of products used in day-to-day life. First 10 Lesson Plans in the series are released on the occasion of World Consumer Rights Day on 15 Mar 2023. Second Set of 10 Lesson Plans were released on 10 Jun 2023 by Hon'ble Minister of State during the Governing Council Meeting of BIS.

The Lesson Plans are expected to serve as a useful tool for the teaching fraternity for imparting knowledge on scientific laws and principles through their practical applications in activities and products around us and facilitate an interactive learning experience for the students.

Stainless Steel

Steel is an alloy comprised of iron and carbon, so the history of its manufacture begins with iron-making. Iron is commonly found in the Earth's crust in the form of an ore, usually an iron oxide, such as magnetite or hematite.

Archaeologists believe that iron was discovered in ancient Egypt somewhere between 5000 and 3000 BCE. During this time, they hammered or pounded the metal to create tools and weapons. They found and extracted it from meteorites and used the ore to make spearheads, tools and other trinkets. The earliest evidence for smelted iron in India dates to 1300 to 1000 BCE.

Iron Age iron was forged using processes that often meant that by products like charcoal were included in the final product. The carbon from this charcoal changed the properties of Iron, and with more than 0.8 percent carbon content, Iron is found to be very hard and brittle – the first genuine steel. Many cultures, such as the Egyptians and the Chinese, further found that this steel could be reheated and tempered to make it less brittle.

Harry Brearley invented the first true Stainless Steel in 1913. He added 12.8% chromium to Iron, and produced an alloy that he found was resistant to both corrosion and rust. Brearley discovered this metal while looking for a solution to the problem of erosion in the gun barrels of the British army. The alloy was initially called rustless steel and was later renamed Stainless Steel.

Stainless steel contains more than 11% chromium and may contain other elements to obtain other desired properties. Stainless steel's resistance to corrosion results from the Chromium, which forms a passive oxide film that can protect the material and self-heal in the presence of oxygen.

The alloy's properties, such as toughness and resistance to corrosion, are useful in many applications. Stainless steel can be rolled into sheets, plates, bars, wire, and tubes. These can be used in cookware, cutlery, surgical instruments, major appliances, vehicles, construction material in large buildings, industrial equipment (e.g., in paper mills, chemical plants, water treatment), and storage tanks and tankers for chemicals and food products. Stainless steel is 100% recyclable and can be reprocessed without degradation, which keeps it out of the waste stream. Its high resistance to corrosion means it has a long service life before needing replacement. Almost 98% of the Iron and Steel

used is recycled, making it environment friendly. These qualities can help with the task of reducing carbon emissions and forging more sustainable practices.

1. Terms and Concepts

Before we go into details let's learn about some important concepts and terminologies pertaining to stainless steel.

a) **Mixture:** A mixture contains more than one substance (element and/ or compound) mixed in any proportion. Mixtures can be separated into pure substances using appropriate separation techniques. Additionally, a mixture shows the properties of its constituents unlike compounds.

b) **Alloy:** Alloy is a mixture of two or more metals or a metal and a non-metal

c) **Steel:** Iron is an alloy of Iron and Carbon. Iron when mixed with a small amount of carbon (0.02 to 2.1 % by mass), it becomes steel. Steel may also contain other alloying elements.

d) **Corrosion:** When a metal is attacked by substances around surface such as oxygen, moisture, acids, etc. and the metal is chemically changed, it is said to be corroded and this process is called corrosion. Iron when exposed to moist air for a long time acquires a coating of a brown flaky substance called rust. It is an example of corrosion.

e) **Stainless Steel:** Stainless steel is an alloy of Iron, Carbon and at least 11% Chromium.

2. Stainless Steel Types

There are four main types of Stainless Steel depending upon the phase of the Iron in the alloy: Ferritic, Austenite, Martensitic, and Duplex.

a) **Austenitic**

In this type of Steel, Iron exists in Face Centred Cubic (FCC) Structure. This is the most widely used type of Stainless Steel, known for its excellent corrosion resistance and high malleability. They are extremely formable and weldable, and they can be successfully used from cryogenic temperatures (-269°C) to the red-hot temperatures of furnaces (1000°C) and jet engines. Austenitic stainless steel contains high levels of chromium (typically 18% to 26%) and nickel (typically 8% to 10.5%), along with low carbon content. It is non-magnetic and can be easily formed and welded. Common grades include SS 304 used for utensils and SS 316 (higher corrosion resistance).

b) **Ferritic**

In this type of Steel, Iron exists in Body Centred Cubic (BCC) Structure. Ferritic stainless steel has a higher Chromium content than Austenitic Stainless Steel (typically 11% to 27%) but a lower nickel content. It is magnetic and has good corrosion resistance in certain environments. It differs from other forms of stainless steel in two ways: its molecular grain structure and its chemical composition.

Ferritic stainless steel is less malleable and formable compared to austenitic stainless steels. Grades such as 430 and 446 are commonly used in applications where high-temperature resistance is required.

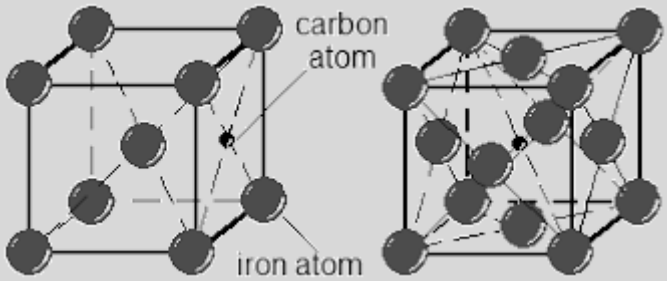
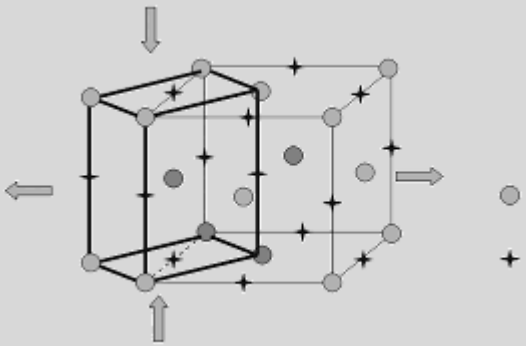


Image shows Body Centred Cubic and Face Centred Cubic structures of Iron atoms in Ferrite Phase and Austenite Phase respectively. The carbon atom is shown in dark black.

c) Martensitic

In this type of Steel, Iron exists in Body Centred Tetragonal (BCT) Structure. Martensitic Stainless Steel has high Carbon content (typically 0.1% to 1.2%) and moderate Chromium content (typically 11.5% to 18%) and is known for its high strength and hardness. Because of its chemical composition, it can be hardened and strengthened through heat treatment and aging. These methods make Martensitic steel stronger than other types which makes it a good choice for the fabrication of medical instruments, mechanical valves, turbine parts, mechanical instruments, and other various applications. However, it has lower corrosion resistance compared to Austenitic and Ferritic Stainless Steels. Grade 410 is a commonly used Martensitic Stainless Steel.



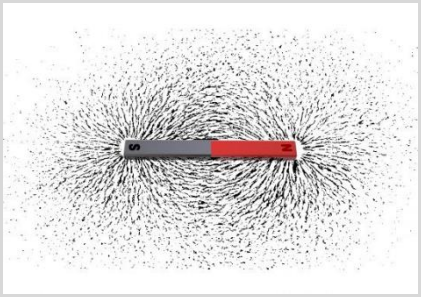
Martensite phase of Iron has is Body Centred Tetragonal, this is achieved by suddenly cooling steel from high temperatures. The steel changes crystal structure from FCC to BCC during cooling from above 721°C to Room Temperature. However if the steel is suddenly cooled, the atoms get insufficient time for re-arrangement and the Iron gets BCT Structure.

d) Duplex

Duplex stainless steels are Fe-Ni-Cr alloys consisting of ferritic-austenitic microstructure at room temperature. These steels generally possess beneficial combinations of the austenitic and ferritic phases. Duplex stainless steels exhibit greater toughness and better weldability than ferritic stainless steel. They have higher strength and better corrosion

resistance than austenitic stainless steel. Their good engineering performance has led to an increasing number of applications, mainly in corrosive environments such as sour gas pipelines and chemical reaction vessels. Duplex stainless steel are also magnetic, a property that can be used to easily differentiate them from common austenitic grades of stainless steel. Grades such as 2205 and 2507 are commonly used in applications where both corrosion resistance and strength are important.

3. Magnetism of Iron and Steels



Magnetism is a force that can attract or repel certain materials. Magnets have two poles, called the north pole and the south pole. Opposite poles attract each other, while like poles repel each other. The magnetic force can be used to do many things, such as picking up paper clips, making compasses work, and generating electricity. Common magnetic materials are Iron, Cobalt and Nickel.

Magnetism is a fundamental force of nature, just like gravity. It is caused by the alignment of spin of electrons in an atom.

Magnetism is all around us. The Earth itself is a magnet, and the magnetic force is what helps us to navigate using compasses. Magnets are also used in many everyday objects, such as motors, and speakers.

4. Manufacturing Process

Stainless Steel is formed when the Iron, Chromium, Nickel, Silicon, Molybdenum, etc. are melted together. Different proportions of elements in Stainless Steel like Nickel, Chromium, Molybdenum, etc. determine the type and property of stainless steel. The ratio of Iron to other materials affects how strong the protective oxide layer is and thereby how resistant the metal is to specific corrosion and properties like hardness, melting point, shear modulus, etc.

The different raw materials required for Stainless Steel are fed into a furnace (typically an induction furnace or an electric arc furnace for modern stainless steel manufacturing applications) and heated to their melting point. This results in molten metal of Iron, Chromium, and other elements.

The excess carbon present in the molten metal is removed by Decarburization method where Carbon is oxidized by injecting controlled amounts of Oxygen gas. Depending on how much carbon is removed, this process could result in a standard or a low-carbon variant of the alloy and can affect the tensile strength and hardness of the final product.

a) **Tuning or Stirring.** To help fine-tune the quality of the final product, the molten steel may be stirred to help distribute and/or remove specific stainless steel components from the mixture. This helps to ensure that the stainless steel is of uniform quality and will meet the specifications required by end users.

b) Forming the Metal. As the stainless steel begins to cool, it is put through a variety of casting and forming processes starting with continuous casting into blooms, billets and slabs, followed by hot rolling while the steel is still above its crystallization temperature. Hot rolling helps steel attain a rough shape generally sufficient for ease in transportation and further processing. Desired dimensions are obtained by cold rolling into finished products

c) Heat Treatment/Annealing. To relieve internal stresses and alter the stainless steel's mechanical properties, steel may be heat treated at different temperatures and subsequently cooled differently. Each of the treatment imparts different properties to the steel due to crystal structure and grain sizes.

d) Cutting and Shaping. After the annealing process, stainless steel is put through a variety of cutting and shaping processes to create an ideal final product for the application. The specific operations used to cut the stainless steel will vary depending on the size and shape of the billet/bloom and the desired final product.

e) **Applying Surface Finishes.** The stainless steel manufacturer may apply different surface finishes to their stainless steel billets, blooms, or wires before shipping them to other manufacturers. The specific finish applied will vary depending on the steel's intended use but one of the most common surface finishes is simply grinding down the surface to remove impurities and make it smoother.

5. Heat Treatment of Steels

There are 4 common heat treatments for steel,

a) Annealing

It is a heat treatment where Steel heated to high temperature above its recrystallization temperature and maintained for appropriate time and is slowly cooled under same furnace conditions. As the material cools it recrystallizes from liquid to solid. In annealing, atoms re-arrange is their most preferred locations and form a favourable crystal structure leading to high ductility and high grain size.

Grains are crystals with atoms solidified into a single crystalline form. Image shows grains on Zinc on Galvanized Iron. Iron is galvanized with Zinc coating for protections against corrosion. Grains in steel are much smaller and can be viewed only through a microscope.

b) Normalizing

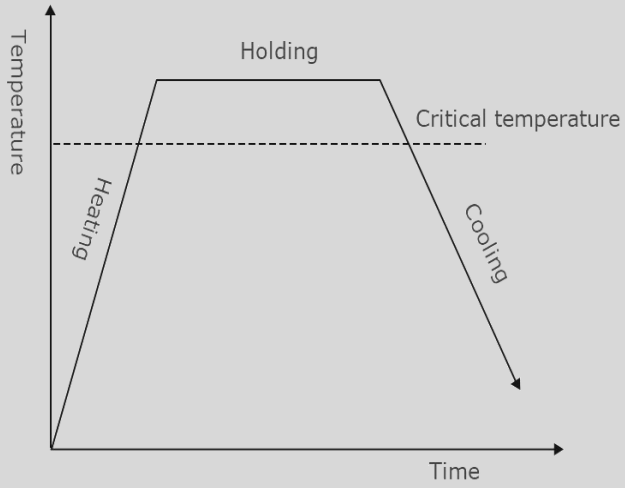
It is a heat treatment where Steel after heating is cooled in air, the cooling rate is faster than that in Annealing with less time for grain growth. Hence the grains formed are smaller and Steel thus formed in stronger but with less malleability and ductility.

c) Quenching

It is a heat treatment where the Steel is immersed in water or salt water for immediate cooling. This results in steel with Iron in BCT crystal structure which has high strength but brittleness. Brittle steels tend to crack due to high impact force and considered inferior with low toughness.

d) Tempering

Tempering is a heat treatment where the brittle steel after quenching can be improved in its toughness property. The steel is heated again to comparatively low temperatures around 250°C where the atoms diffuse and obtain favourable locations in the crystal structure thereby improving the toughness of the steel at the same time retaining high strength.



6. Properties of Stainless Steel

a) Corrosion Resistance: Stainless steel is known for its exceptional resistance to corrosion and oxidation. The presence of chromium in stainless steel forms a passive oxide layer on the surface, which protects it from environmental factors like moisture, chemicals, and gases. This property enables stainless steel to maintain its integrity and appearance even in harsh and corrosive environments.

b) High Strength: Stainless steel offers high strength and excellent mechanical properties. It exhibits good tensile strength, allowing it to withstand heavy loads and resist deformation. Stainless steel's strength can be further enhanced through various heat treatment processes.

c) **Heat Resistance:** Stainless steel exhibits remarkable heat resistance, making it suitable for applications involving high temperatures. It retains its strength and structural integrity at elevated temperatures, making it ideal for use in industrial furnaces, exhaust systems, and aerospace components.

d) **Aesthetic Appeal:** Stainless steel has an attractive and modern appearance, making it popular for architectural and decorative applications. Its lustrous surface can be polished or brushed to achieve different finishes, allowing for customization in design.

e) **Durability and Longevity:** Stainless steel is highly durable and has a long lifespan. It can withstand harsh environmental conditions, including exposure to UV radiation, moisture, and temperature fluctuations, without significant degradation. This durability reduces the need for frequent replacements, making stainless steel a cost-effective choice in the long run.

f) **Formability and Weldability:** Stainless steel is highly formable and can be fabricated into various shapes and sizes. It can be easily bent, cut, welded, and formed without losing its properties. This versatility allows for customization and adaptation to specific design requirements.

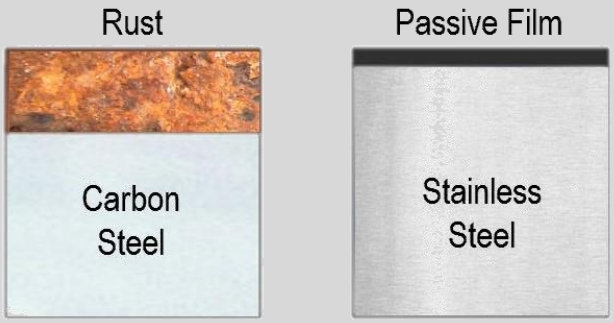
g) **Low Maintenance:** Stainless steel requires minimal maintenance due to its corrosion resistance and durability. It does not require protective coatings or frequent cleaning, saving time and costs in maintenance efforts. It higher strength also means it has high lifespan under loads.

h) **Recyclability:** Stainless steel is 100% recyclable without losing its properties. It can be melted down and reused to create new stainless-steel products, making it an environmentally friendly choice.

i) **Magnetism Variability:** Stainless steel can exhibit different magnetic properties depending on its composition. Austenitic stainless steel is generally non-magnetic, while ferritic and martensitic stainless steels are magnetic. This property allows for specific applications where magnetic or non-magnetic characteristics are required.

7. Principle of Corrosion Resistance in Stainless Steel

Chromium present in Stainless steel, oxidizes quickly in the presence of oxygen and produces a stable, passive oxide film on exposed surfaces. This corrosion-resistant film can be 5 nm thick and protects the stainless steel from rusting/corrosion. It contains varying amounts of Cr_2O_3. In an oxidizing medium, any defect in the film that arises through abrasion is quickly repaired (i.e., the film is self-healing). However, it must always be remembered that no stainless steel is completely corrosion-proof, and oxygen is required to maintain passivity and to restore passivity after acid-treatment.

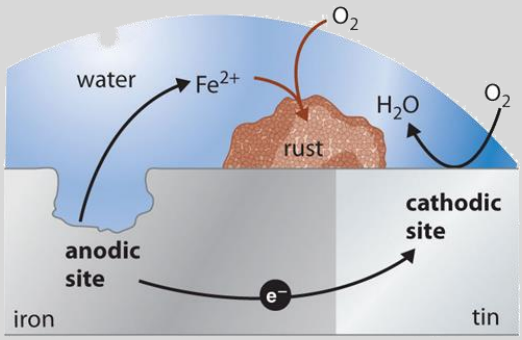


Steel corrosion in conducive environment is an electrochemical process in which iron (Fe) is removed from the steel being corroded and is dissolved into the surrounding solution; it then appears as ferrous ions (Fe^{2+}).

In other words, Steel corrosion is the irreversible deterioration of the steel material and its vital properties due to the electrochemical reaction of its surface to environmental factors such as acids, moisture, and oxygen.

Steel corrosion involves an electrolysis in which the metallic surface releases electrons into an electrolyte, such as a layer of moisture in the presence of oxygen. Iron in the steel in the environment of moist air will tend to go back to its original state of iron oxide as rust. Steel can be corroded by the chemical reaction of certain chemicals like sulfuric acid.

The rate of steel corrosion is affected by factors such as ambient air temperature, presence of chemical fumes and vapours, as well as humidity. In the case of buried steel structures and pipes, the composition of the soil and its moisture influence the extent of corrosion and its impact. The corrosive reaction changes the microstructure of the steel on its surface, thus making it brittle and flaky. Slowly it loses its mechanical strength and elasticity. Thus, the useful life of steel structures and other applications are severely curtailed. Hence, there is a need to apply suitable protective coating, depending upon the type of application and environment. One of the such protective coating is Galvanization in which Zinc is coated over steel. Some alloys of steel like Stainless Steel have inbuilt corrosion resistance.



Activity

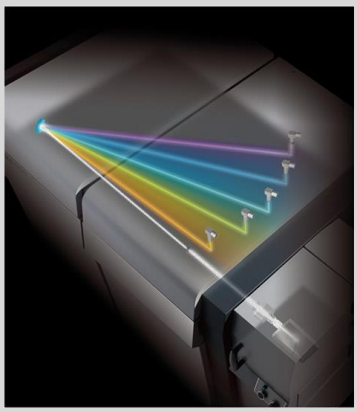
1. Look at your surroundings and list the product made with stainless steel and discuss why these products are made of stainless steel.
2. What do you think corrosion is and how it affects iron?
3. Are rusting and corrosion the same?
4. What other types of steel have you heard of? List few properties of these steels?

8. Chemical & Mechanical Analysis

Chemical Analysis: As we learned alloying of Cr, Ni, Mo, and N improves corrosion properties of stainless steel, therefore, knowledge of these parameters plays significant role in stainless steel industries. Based on chemical composition, various grades of stainless steel are manufactured by the industries. Now the question that comes in our mind is how these parameters (Cr, Ni, Mo, N) are determined by the industry and how much time it takes?

The industries have to do continuous production to meet the demand while maintaining quality of material and to achieve the required quality, high frequency of testing is needed. To achieve this, frequent chemical analysis of stainless steel is required. This chemical analysis method uses a spectrometer and based on its principle various types of spectrometers are available e.g., Atomic-Absorption Spectrometer.

In order to analyse a sample for its atomic constituents, it has to be atomized. The atomizers most commonly used nowadays are flames and electrothermal (graphite tube) atomizers. The atoms should then be irradiated by optical radiation, and the radiation source could be an element-specific line radiation source or a continuum radiation. The radiation then passes through a monochromator in order to separate the element-specific radiation from any other radiation emitted by the radiation source, which is finally measured by a detector.



In short, a optical light is passed through the atoms and analysed on sensor at the opposite end. Each chemical element absorbs a wavelength/colour of the light. The missing wavelength or colour of the light indicates presence of a certain chemical element.

Chemical test method such as gravimetric and volumetric method are also being used to determine the chemical composition. Muffle furnace, hot plate, titration flask, burette, pipette, various chemicals etc. are used to determine the certain element. However, chemical method takes a lot of time, sometimes days.

Mechanical Analysis: Various mechanical properties of stainless steel are determined for their applicability for certain purposes. Let's talk about these properties and testing methods used by labs for their determination.

a) **Tensile test:** It is a test in which a sample is subjected to a controlled tensile force until failure. Properties that are directly measured via a tensile test are ultimate tensile strength, breaking strength, maximum elongation and reduction in area. From these measurements the following properties can also be determined:

- Young's modulus,
- Poisson's ratio,
- Yield strength, and
- Strain-hardening characteristics.

Tensile strength: Tensile strength is the amount of load or stress that can be handled by a material before it stretches and breaks.

Yield strength: When a force is applied to an object, the object experiences elastic deformation at first. The object will return to its original size and shape when the force is removed as long as the resulting stress does not exceed the yield stress.

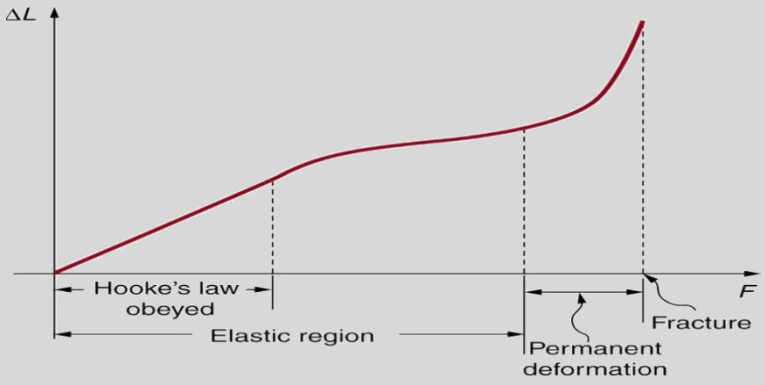
b) Hooke's Law and study of deformation

A change in shape due to the application of a force is a deformation. Even very small forces are known to cause some deformation. For small deformations, two important characteristics are observed. First, the object returns to its original shape when the force is removed i.e., the deformation is elastic for small deformations. Second, the size of the deformation is proportional to the force i.e., for small deformations, **Hooke's law** is obeyed. It states that "when an object has a relatively small deformation the size of the deformation is directly proportional to the deforming load or force".

$$\boldsymbol{F = k.\Delta L}$$

Where, ΔL is the amount of deformation produced by the force F, and k is a proportionality constant.

A graph of deformation ΔL versus applied force F is shown. The straight line in the initial loading indicates, deformation is directly proportional to the load.

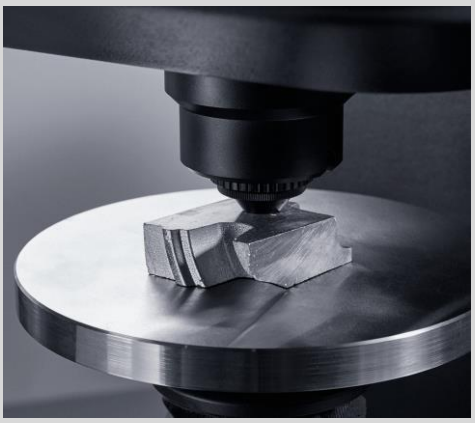


a) Bend Test

The bending test of steel performed to verify steel ductility and to ensure that no fracture or cracks will occur during the bending.

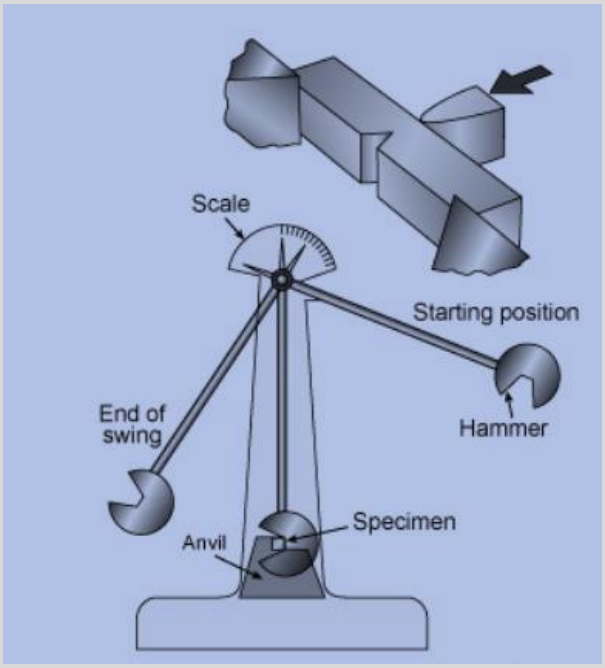
b) Hardness

Hardness is the ability of a material to resist deformation at surface, which is determined by a standard test where the surface resistance to indentation is measured. The most commonly used hardness tests are defined by the shape or type of indent, the size, and the amount of load applied. Hardness can also be defined as resistance to scratch and indentation on surface of a material. Test methods used to determine hardness are Brinell Hardness Test, Vickers Hardness Test, Rockwell Hardness Test.



c) Impact Test

This test is used to determine impact strength of a material. The impact strength of a material is defined as its capability to resist a sudden applied load or force. It is normally conveyed as the amount of mechanical energy absorbed in the process of deformation under the applied impact loading and is expressed as energy lost per unit of thickness. Two such types of impact tests are: Charpy Impact Test and Izod Impact test.



d) Corrosion Test

To determine whether the stainless steel sufficiently resists corrosion, following tests are performed: Huey Test (Nitric Acid Medium), Monypenny Strauss Test.

9. Interesting Facts

(i) Stainless steel was discovered accidentally: In 1913, Harry Brearley, a British metallurgist, was attempting to develop a more erosion-resistant steel for gun barrels. He discovered that adding chromium to steel created a material that was highly resistant to corrosion, giving birth to stainless steel.

(ii) Stainless steel is 100% recyclable: Stainless steel is one of the few materials that can be recycled indefinitely without losing its properties. It can be melted down and reused to create new stainless steel products, making it an environmentally friendly choice.

(iii) It is used in various industries: Stainless steel is widely used in industries such as construction, automotive, aerospace, food processing, medical, and more. Its versatility, corrosion resistance, and hygienic properties make it a popular material choice in these sectors.

(iv) Stainless steel is self-healing: When stainless steel is scratched or damaged, it forms a protective oxide layer on the surface, which acts as a self-healing barrier against further corrosion. This property, known as passivation, contributes to the durability and longevity of stainless steel.

(v) It can withstand extreme temperatures: Stainless steel exhibits excellent heat resistance and can withstand high temperatures. This property makes it suitable for applications such as kitchen utensils, industrial ovens, exhaust systems, and jet engine components.

(vi) Stainless steel is hygienic: The smooth, non-porous surface of stainless steel makes it easy to clean and maintain, which is why it is widely used in the food processing and medical industries. It is resistant to bacteria, making it a safe and sanitary choice.

(vii) Available in different finishes- Common finishes include brushed, mirror-polished, satin, and textured finishes, allowing for aesthetic customization.

(viii) It is used in architectural applications: Stainless steel is commonly used in architectural structures, such as bridges, buildings, and monuments, due to its durability, aesthetic appeal, and resistance to corrosion in outdoor environments.

(ix) While Iron is magnetic most stainless steel is non-magnetic, certain grades, such as ferritic stainless steel, exhibit magnetic properties. This magnetic property can be useful in applications such as magnetic separators or when handling magnetic materials.

10. Questions

Q1. What is the primary alloying element in stainless steel that provides corrosion resistance?
a) Chromium
b) Nickel
c) Manganese
d) Carbon
Answer: a) Chromium

Q2. Which type of stainless steel is known for its high strength and hardness?
a) Austenitic stainless steel
b) Ferritic stainless steel
c) Martensitic stainless steel
d) Duplex stainless steel
Answer: c) Martensitic stainless steel

Q3. What is the purpose of the passivation process in stainless steel manufacturing?
a) To increase hardness
b) To improve ductility
c) To enhance corrosion resistance
d) To reduce magnetism
Answer: c) To enhance corrosion resistance

Q4. Which test is commonly used to measure the corrosion resistance of stainless steel?
a) Tensile test
b) Hardness test
c) Impact test
d) Salt spray test
Answer: d) Salt spray test

Q5. Which type of stainless steel is suitable for high-temperature applications?
a) Austenitic stainless steel
b) Ferritic stainless steel
c) Martensitic stainless steel
d) Duplex stainless steel
Answer: a) Austenitic stainless steel

Q6. Which test is used to determine the mechanical properties of stainless steel, such as yield strength and elongation?
a) Charpy test
b) Brinell test
c) Rockwell test
d) Tensile test
Answer: d) Tensile test

Q7. What is the purpose of heat treatment in stainless steel manufacturing?
a) To remove carbon content
b) To change chemistry of alloy
c) To enhance hardness and strength
d) To reduce magnetism
Answer: c) To enhance hardness and strength

Q8. What is the most common method of joining stainless steel?
a) Welding
b) Brazing
c) Soldering
d) Riveting
Answer: a) Welding

Q9. What is Galvanizing?
a) Adding Chromium to Stainless Steel
b) Coating Zinc on Iron
c) Painting on Steel
d) Acid treatment of Stainless Steel
Answer: b) Coating Zinc on Iron

Q10. What is Quenching?
a) Cooling steel in air from high temperature
b) Cooling steel in water from high temperature
c) Cooling steel in furnace from high temperature
d) Heating steel to high temperature
Answer: b) Cooling steel in water from high temperature

Lesson Plan Subjects

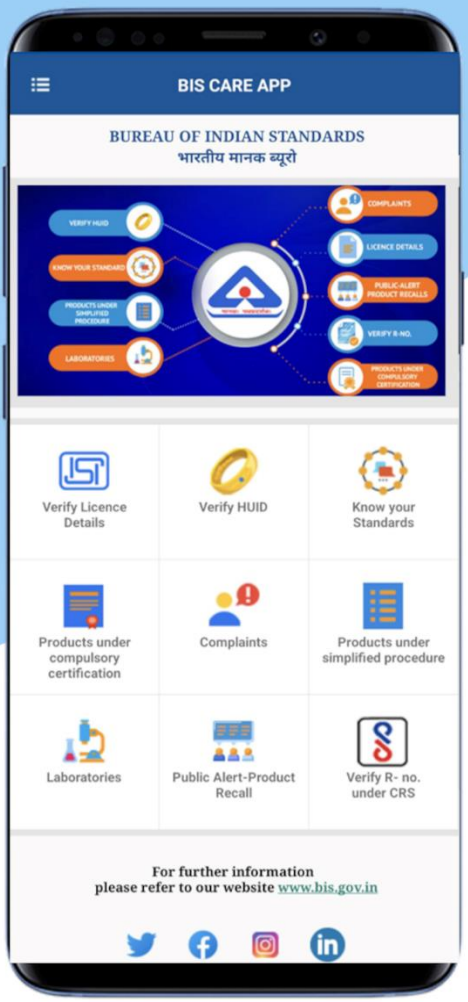
Published

1.	Caustic Soda	**16.**	Headphones
2.	Football	**17.**	Milk Powder
3.	Cement	**18.**	Pressure Cooker
4.	Gas Stove	**19.**	Plywood
5.	Geyser	**20.**	Multipurpose dry batteries
6.	Helmet	**21.**	Ballpoint Pen
7.	LED Bulb	**22.**	Bicycle
8.	LPG Cylinders	**23.**	Electric Iron
9.	Cement Ash Brick	**24.**	Loudspeakers
10.	Paints	**25.**	Pasteurized Milk
11.	Boric Acid	**26.**	Paver Blocks
12.	Ceiling Fan	**27.**	Plugs and Socket
13.	Cables	**28.**	Solar Flat Plate Collectors
14.	Ceramics Tiles	**29.**	Precast Concrete
15.	Rear View Mirrors	**30.**	Stainless Steel

Forthcoming…

31.	Drinking Water	**42.**	PVC Pipes
32.	Electric Mixer	**43.**	Refrigerator
33.	Family Sized Biogas Plant	**44.**	Solid and Hollow Block
34.	Fire Extinguisher	**45.**	Steel Bar
35.	Power Threshers	**46.**	Submersible Pump set
36.	Conduits	**47.**	Thermometer
37.	CNG Cylinders	**48.**	Tyres for buses and trucks
38.	Hearing Aids	**49.**	Vacuum Flask
39.	Microwave Oven	**50.**	Water Meter
40.	Water Storage Tank	**51.**	Wheel Rim
41.	Weighing balance	**52.**	Geosynthetics

BIS CARE APP



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- Get locations of BIS labs and Offices.
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- Register complaints regarding quality of Product of misuse of ISI mark by using 'Complaints'
- You can also access products under compulsory certifiction of BIS & Products under simplified procedure of licensing.

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BUREAU OF INDIAN STANDARDS

(THINK, NUDGE, & MOVE DEPARTMENT)

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