Department of Mechanical Engineering
Materials Science Lab

Laboratory in charge

Prof. Rupendra S. Tanwar
Prof. Sonali Yadav

Laboratory Technician

Mr. Suraj Kalsekar

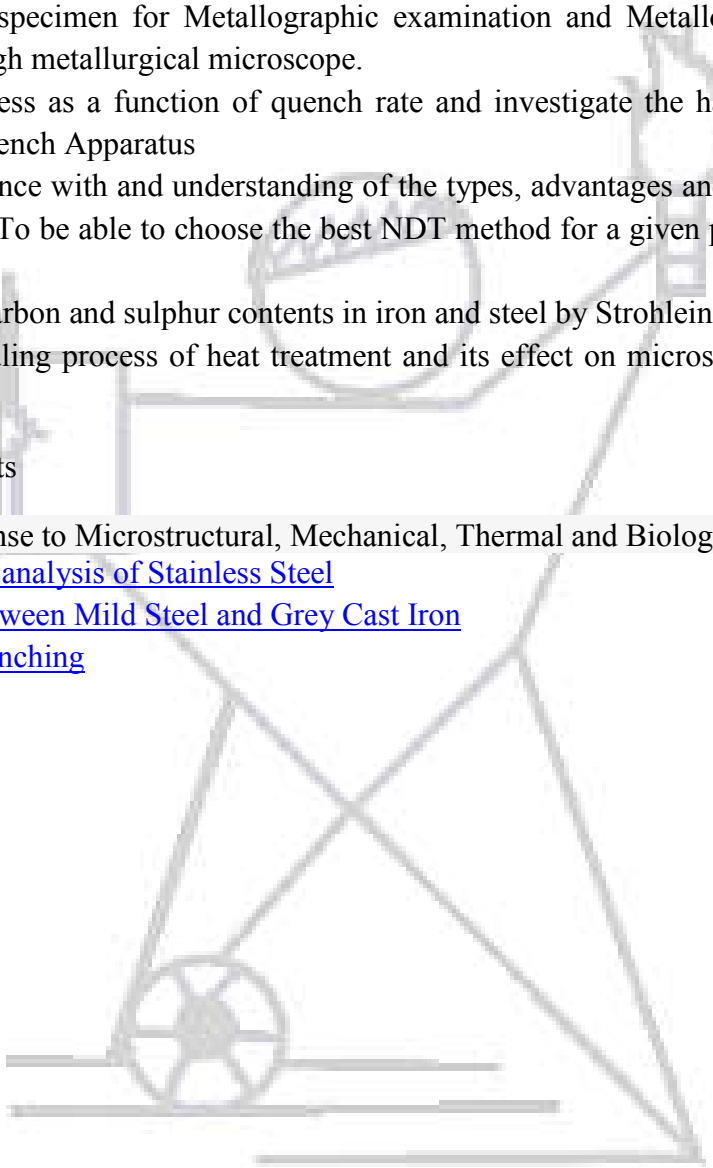
List of Experiments

Materials Science (PCC ME-301)

1. To study the Erichsen sheet metal testing machine & perform the Erichsen sheet metal test
2. Preparation of specimen for Metallographic examination and Metallographic study of given specimen through metallurgical microscope.
3. To study hardness as a function of quench rate and investigate the hardenability of steels by Jominy End Quench Apparatus
4. To gain experience with and understanding of the types, advantages and applications of various NDT methods. To be able to choose the best NDT method for a given part and perform Test on UFD machine.
5. To determine carbon and sulphur contents in iron and steel by Strohlein's Apparatus.
6. Study of Annealing process of heat treatment and its effect on microstructure and Mechanical Properties.

Virtual Lab Experiments

1. Material Response to Microstructural, Mechanical, Thermal and Biological Stimuli Lab
2. Microstructural analysis of Stainless Steel
3. Comparison between Mild Steel and Grey Cast Iron
4. Severity of Quenching



List of Equipments with Price

S.NO.	LIST OF EQUIPMENTS	QTY.	Amount (in Rupees)	Date of purchasing	Remarks
1	Upright Metallurgical Microscope, Digital	1	153540/-	29/03/2019	
2	Dewinter Material Plus Software 4.5 Ver.	1	96030/-	29/03/2019	
3	Double Disc Polishing Machine	1	28800/-	29/03/2019	
4	Strauhlein's Apparatus	1	43312.5/-	29/03/2019	
5	Jominey End Quench Apparatus	1	27000/-	29/03/2019	
6	Electrical Muffel Furnace	1	54000/-	29/03/2019	
7	UFD Machine Make: RTUL Model UF	1	160875/-	29/03/2019	
8	Erichsen Cupping Testing Machine	1	53069.5/-	29/03/2019	
Total			6,16,627/-		

List of Major Equipments with Price

S.NO.	**LIST OF Instrument**	**QTY.**	**RATE**
1	Upright Metallurgical Microscope, Digital	1	153540
2	Electrical Muffel Furnace	1	54000
3	Double Disc Polishing Machine	1	28800

List of Equipments purchased in Last Five Years with Price

S.NO.	LIST OF EQUIPMENTS	QTY.	Amount (in Rupees)	Date of purchasing	Remarks
1	Upright Metallurgical Microscope, Digital	1	153540/-	29/03/2019	
2	Dewinter Material Plus Software 4.5 Ver.	1	96030/-	29/03/2019	
3	Double Disc Polishing Machine	1	28800/-	29/03/2019	
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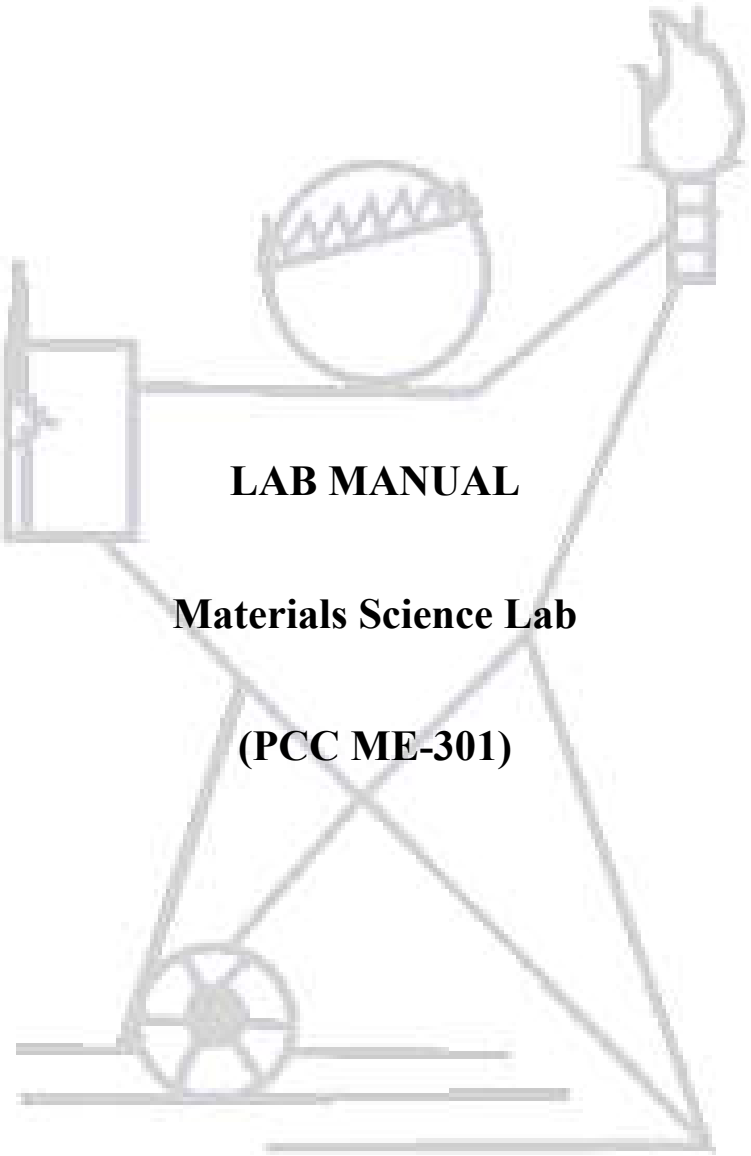


LAB MANUAL

Materials Science Lab

(PCC ME-301)

IPS Academy, Indore

Institute of Engineering & Science
Mechanical Engineering Department

LAB MANUAL

Materials Science Lab

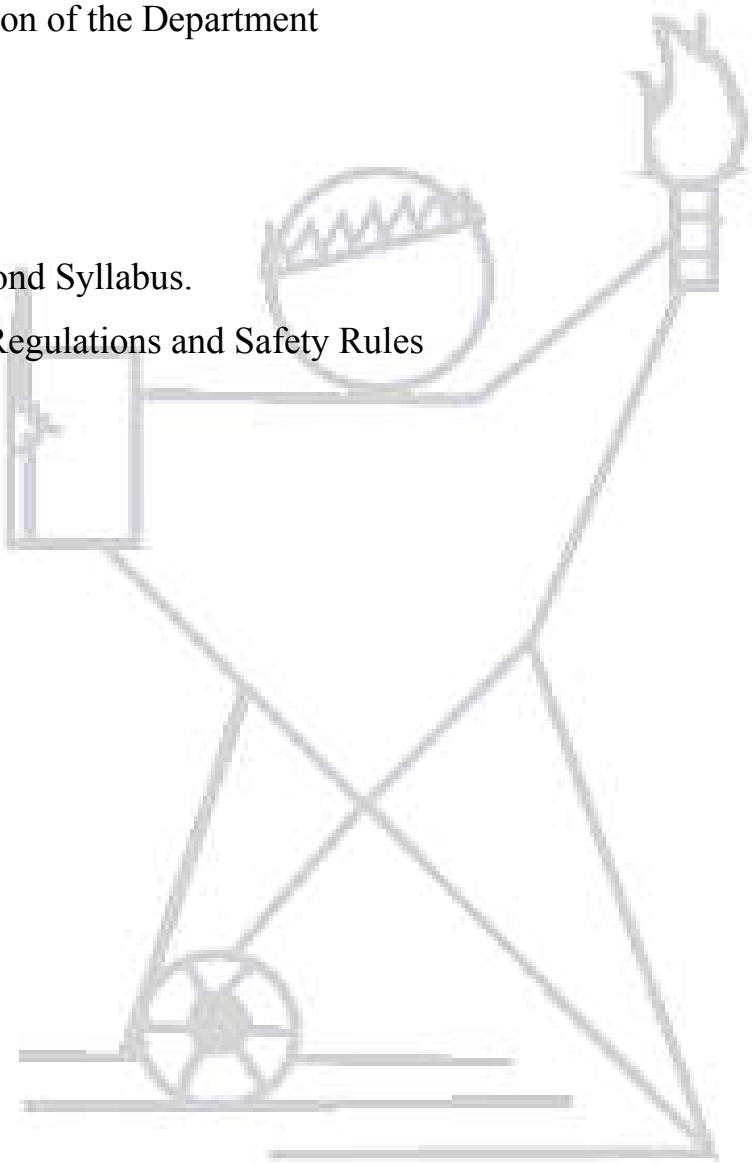
(PCC ME-301)

Name …….

Session ……Semester …….

Enrollment No. ……..

Contents



Vision of the Institute

To be the fountainhead of novel ideas & innovations in science & technology & persist to be a foundation of pride for all Indians.

Mission of the Institute

M1: To provide value based broad Engineering, Technology and Science where education in students is urged to develop their professional skills.

M2: To inculcate dedication, hard work, sincerity, integrity and ethics in building up overall professional personality of our student and faculty.

M3: To inculcate a spirit of entrepreneurship and innovation in passing out students.

M4: To instigate sponsored research and provide consultancy services in technical, educational and industrial areas.

Vision of the Department

To be a nationally recognized, excellent in education, training, research and innovation that attracts, rewards, and retains outstanding faculty, students, and staff to build a Just and Peaceful Society.

Mission of the Department

M1: Imparting quality education to the students and maintaining vital, state-of-art research facilities for faculty, staff and students.

M2: Create, interpret, apply and disseminate knowledge for learning to be an entrepreneur and to compete successfully in today's competitive market.

M3: To inculcate Ethical, Social values and Environment awareness.

Program Education Objectives (PEOs)

PEO1: To enrich graduates with fundamental knowledge of Physics, Chemistry and advanced mathematics for their solid foundation in Basic Engineering science.

PEO2: To provide graduates to design the solution of engineering problems relevant to mechanical engineering design through the process of formulating, executing & evaluating a design solution as per need with socio-economic impact consideration and related constraints.

PEO3: To provide graduates with experience in learning and applying tools to solve theoretical and open ended mechanical engineering problems.

PEO4: To provide a contemporary grounding in professional responsibility including ethics, global economy, emerging technologies and job related skills such as written and oral communication skills and to work in multidisciplinary team.

PEO5: Prepare graduates to be interested, motivated, and capable of pursuing continued life-long learning through beyond curriculum education, short term courses and other training programme in interdisciplinary areas.

Program Outcomes (POs)

Engineering Graduates will be able to:

PO1: Engineering knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of Mechanical engineering problems.

PO2: Problem analysis: Identify, formulate, and analyze mechanical engineering problems to arrive at substantiated conclusions using the principles of mathematics, and engineering sciences.

PO3: Design/development of solutions: Design solutions for mechanical engineering problems and design system components, processes to meet the specifications with consideration for the public health and safety, and the cultural, societal, and environmental considerations.

PO4: Conduct investigations of complex problems: An ability to design and conduct experiments, as well as to analyze and interpret data.

PO5: Modern tool usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to mechanical engineering problems with an understanding of the limitations.

PO6: The engineer and society: Apply critical reasoning by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the Mechanical engineering practice.

PO7: Environment and sustainability: Understand the impact of the Mechanical engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

PO8: Ethics: An understanding of professional and ethical responsibility.

PO9: Individual and teamwork: Function effectively as an individual, and as a member or leader in teams, and in multidisciplinary settings.

PO10: Communication: Ability to communicate effectively. Be able to comprehend and write effective reports documentation.

PO11: Project management and finance: Demonstrate knowledge and understanding of engineering and management principles and apply this to Mechanical engineering problem.

PO12: Life-long learning: ability to engage in life-long learning in the broadest context of technological change.

Program Specific Outcomes (PSOs)

PSO1: Engage professionally in industries or as an entrepreneur by applying manufacturing and management practices.

PSO2: Ability to implement the learned principles of mechanical engineering to analyze, evaluate and create advanced mechanical system or processes.

Course Outcomes (COs)

After completion of the course the students are able to-

Course Outcome:

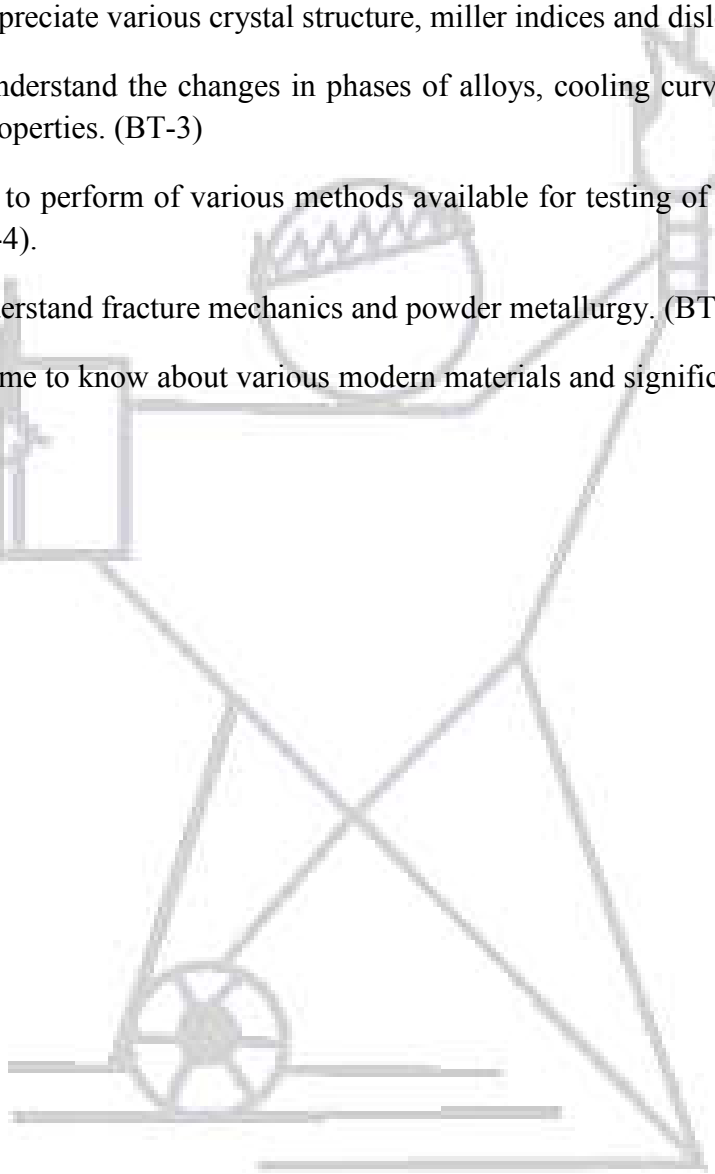
CO1 - Students will appreciate various crystal structure, miller indices and dislocations. (BT-1,2)

CO2 - Students will understand the changes in phases of alloys, cooling curves and heat treatment of metals changes their properties. (BT-3)

CO3- Students will be to perform of various methods available for testing of metals destructively and non-destructively. (BT-4).

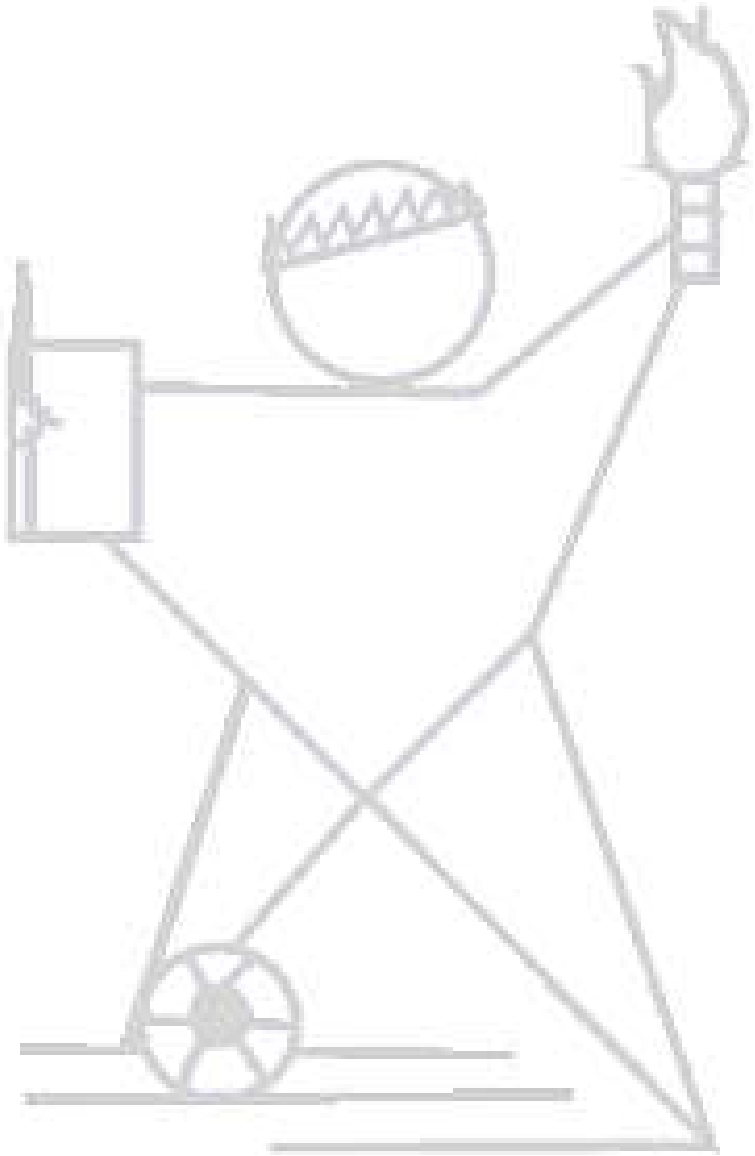
CO4 –Student will understand fracture mechanics and powder metallurgy. (BT-4).

CO5 - Students will come to know about various modern materials and significance. (BT- 2,3).



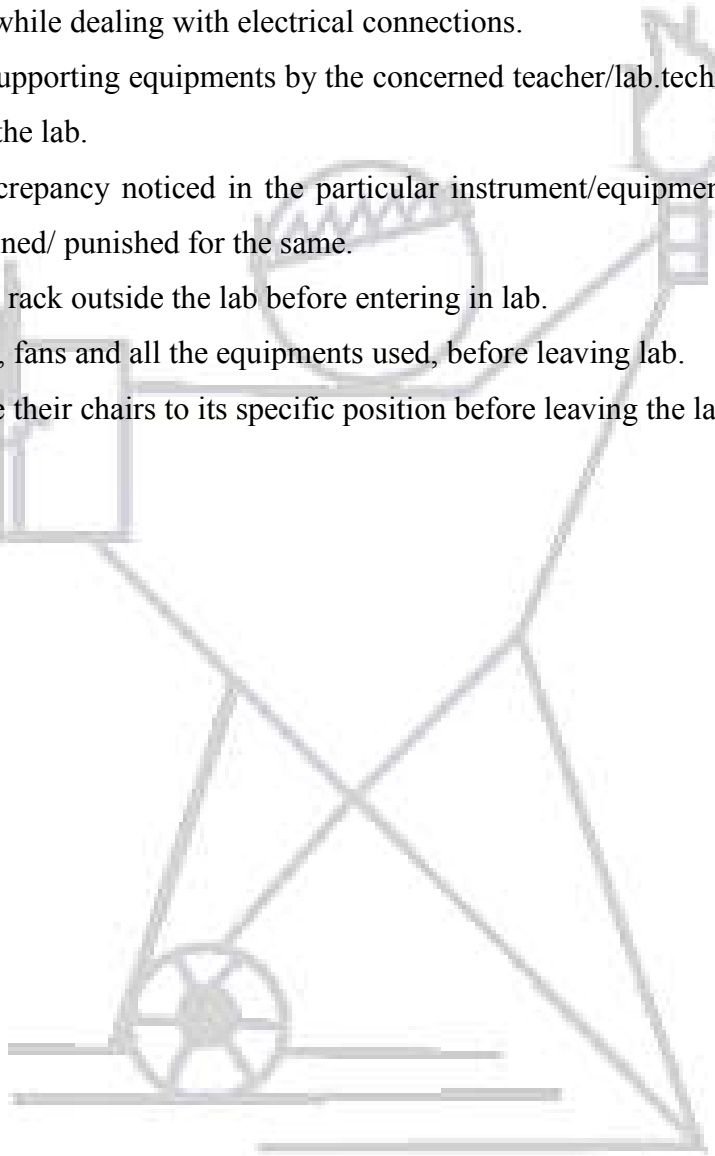
Content beyond syllabus

1. Operations performed on Furnace
2. Operations performed on double disc polishing machine



Laboratory Regulations and Safety Rules

1. Read the instructions mentioned in the manual carefully and then proceed for the experiment.
2. Mishandling of lab equipment will not be tolerated at all. If any student is found guilty; he/she should be punished/ discarded from the lab.
3. Care must be taken while dealing with electrical connections.
4. Issued the needed/ supporting equipments by the concerned teacher/lab.technician & return the same duly before leaving the lab.
5. If any defect or discrepancy noticed in the particular instrument/equipment while the students are using, they will be fined/ punished for the same.
6. Put your bags on the rack outside the lab before entering in lab.
7. Switch off the lights, fans and all the equipments used, before leaving lab.
8. Students will replace their chairs to its specific position before leaving the lab.



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Experiment No 1

Objective: - To study the Erichsen sheet metal testing machine & perform the Erichsen sheet metal test.

Apparatus required: - Cupping test machine, test specimen, vernier calliper, steel rule.

Theory:

This is a mechanical test used to determine the ductility and drawing properties of sheet metal. It consists in measuring the maximum depth of bulge or cup which can be formed before fracture.

Cupping number is the depth of impression at fracture, in the cupping test, usually expressed in millimeters.

Procedure:

1. Measure the dimension of the test piece.
2. Place the test piece in the machine dies and touch the penetrator.
3. Rotate the handle of the machine to penetrate the penetrator in the test piece by pressing the retaining ring.
4. As soon as crack appears in the test piece stop rotating the handle.
5. Determine the depth of cup from med, which is the cupping number.

Observation:-

1. Thickness of test piece: 0.5 to 2 mm.
2. Rotation speed: 5 to 20 mm per minute.
3. Diameter of ball: 20 mm

S.No.	Test piece thickness in mm	Reading		Cupping Number
		Initial	Final	

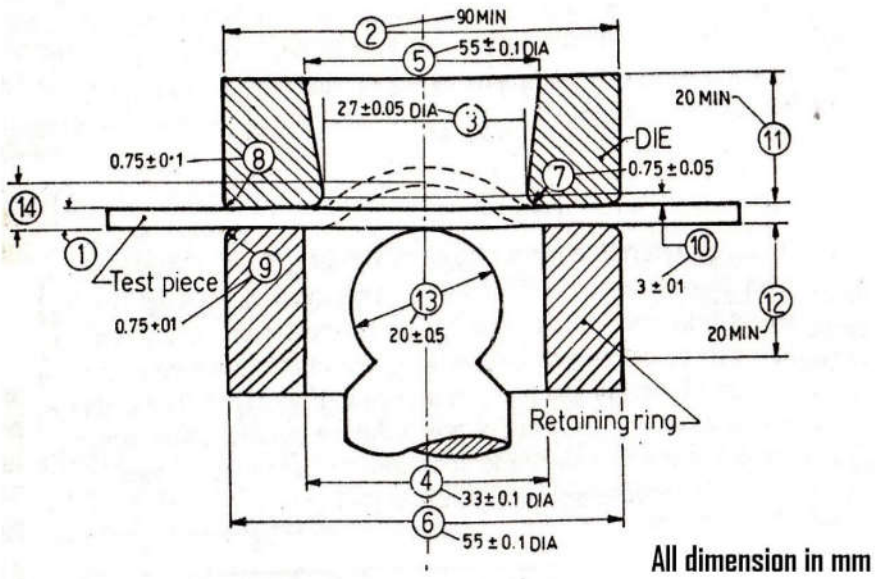


Fig. Schematic of Enrichen cupping test

Precaution:

1. Test piece should be perfectly flat.
2. Test piece should be free from foreign matter.
3. The cup formed should be continuously watched.
4. The handle should be rotated uniformly and continuously.

Sources of error:

1. Handle being rotated with jerks.
2. Test piece not perfectly flat.

Questions:-

1. What is ductility and formability of Metals?
2. Industrial uses of ductility and formability.

Experiment No. 2

Objective: - Preparation of specimen for Metallographic examination and Metallographic study of given specimen through metallurgical microscope.

Apparatus and Material Required:-

Emery papers of different grades, polishing Machine, Etching reagents, Metallurgical Microscope.

Introduction

There are two examination methods in metallography:

1.Macroscopy

2.Microscopy

In macroscopy the examination of the structural characteristics or chemical characteristics of a metal or an alloy is done by the unaided eye or with the aid of a low-power microscope or binocular, usually under l0x.

In microscopy similar examination is done with the prepared metal specimens, employing magnifications with the optical microscope of from 100x to as high as 2000x.

Specimen preparation

1. Grinding

A small piece of specimen is cut by a metal-cutting-saw. After cutting operation, burrs on the edges of the specimen should be carefully removed by a fine file or coarse grinding paper.

The silicon carbide grinding papers are held flat in a unit containing water facility for lubrication purpose. Each unit contains four grades of papers, starting with grade 400 (coarse) and finishing with grade 1200 (fine). Grinding of the work piece is done by starting with the coarse papers and then continuing with the fine papers. In each stage, grinding is done by rubbing the specimen backwards and forwards on the grinding paper in one direction only, until the surface is completely ground, that is, until only grinding marks due to this particular paper can be seen to cover the whole surface.

The specimen is washed thoroughly to remove coarse silicon carbide particles before proceeding to a finer paper.

The direction of grinding is changed from paper to paper, so that the removal of previous grinding marks is easily observed. The extra time spent on each paper should be increased as the finer papers are used. At the end of the grinding sequence, the specimen is washed thoroughly and dried. Now, the specimen is ready for polishing.

2. Polishing

The polishing is done on rotating wheels covered by a special cloth. Alumina is employed as polishing agent. The 1-micron size is commonly used, but the total polishing time shortened by starting on the 7 or 3 micron grade.

The pad should be kept well supplied with lubricant. The specimen should be held firmly in contact with the polishing wheel, but excessive pressure should be avoided. During polishing the specimen should be rotated or moved around the wheel so as to give an even polish. The specimen should be thoroughly cleaned and dried between each wheel.

3. Etching

Before etching, it is essential to ensure that the polished surface is grease and smear free. If the final polishing has involved the use of magnesia (in the form of an aqueous paste of fine magnesia) or alumina (in the form of an aqueous suspension of fine alumina), then thorough washing followed by drying off with acetone or alcohol will give a suitable surface, although it must not be fingered afterwards.

Etching is generally done by swabbing. Etching times will vary from specimen to specimen, however, a good general, procedure is to observe the surface during etching, and to remove the specimen when evidence of the grains first appears. Microscopical examination will then reveal whether the degree of etching is sufficient. Further etching can then follow to strengthen up the details as required.

After each etching, the specimen should be thoroughly washed in running water, followed by drying off with acetone or alcohol. * As a guide the following etchants are commonly used:

Alcoholic Ferric Chloride -copper alloys

Mixed Acids -aluminum alloys

Nital (ethyl alcohol+ 2% HN03) -iron and steel

Dilute HCI -zinc alloys

A. Microscopical Examination

The microstructural study of a material can provide information regarding the morphology and distribution of constituent phases as well as the nature and pattern of certain crystal imperfections. Optical metallography is a basic tool of material scientists, since the equipment is relatively inexpensive and the images can be obtained and interpreted easily. Distribution and morphology of the phases can be studied and, if their properties are known, a quantitative analysis of the micrographs provides some information about the bulk properties of the specimen. A limited study of line and surface informations is also possible with the optical microscope.

In order to obtain reproducible results, with good contrast in the image, the specimen surface is polished and subsequently etched with appropriate reagents before microscopic examination. In a polished specimen, the etching not only delineates grain boundaries, but also allows the different phases to be distinguished by differences in brightness, shape, and color of the grain. Differences in contrast may result from differences in light absorption characteristics of the phases. Etching results in preferential attack or preferential colouring of the surface. The preferential attack is electrochemical corrosion; it is well known that different materials corrode at different rates. Grain boundaries are often anodic to the bulk metal in the interior of the grain and so are etched away preferentially and delineated. Staining is produced by the deposition of solid etch product on the specimen surface. This is formed by chemical reaction between the etchant and the specimen. Under favorable conditions the use of a proper etchant enables the identification of constituents. Failure analysis depends a great deal on metallographic examination.

Microstructural examination can provide quantitative information about the following parameters:

1. The grain size of specimens

2. The amount of interfacial area per unit volume

3. The dimensions of constituent phases

4. The amount and distribution of phases.

Magnifications up to 1000x can be obtained with a resolution of 2 Vm. For grain size measurements, the grains along a line, circle, or within a known area are counted. It would be useful to obtain an

average value of grain diameter from a microstructural section. In linear intercept method, the grains intercepted by a theoretical line on the specimen surface are counted (Fig. 1). The number of grain boundaries intersected per unit length of a test line (n_L) can be noted. The average grain size is indicated by the inverse of n_L, corrected for the magnification, M, of the micrograph. In general, then, the average grain diameter, d, is given by

$d= C/n_L.M$

where C is some constant greater than 1 (Typically, a value of C=1.5 is adequate).

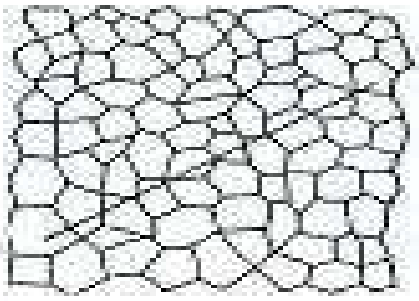


Fig. Linear intercept method for grain size determination

Experimental

Specimens are going to be polished and etched as explained above. With an unmounted specimen, even if it is almost level, it is best to fix it on a glass or metal slide by means of a piece of plasticine. The prepared surface is made level by means of a suitable leveling device.

The correct procedure is to start with low power examination in order to obtain an overall picture, and then successively higher magnifications are used to resolve the fine details. In focusing, the stage is gradually moved towards the objective and when the image appears, focusing is completed with the fine adjustment.

It is almost good practice to examine specimens first in the polished condition,

As certain features, such as the presence of inclusions, cracks, porosity, and sometimes even the different phases, are revealed. This is followed by an examination in the etched condition.

Do not examine one or two fields only. It should always be remembered that the structure of a given specimen exists in three dimensions, whereas the prepared surface represents a two-dimensional picture

in the plane of the micro-section. This fact should be taken into account in the interpretation of the geometry of any particular configuration.

Results

The investigation result of the optical microscopy is going to be recorded as follows:

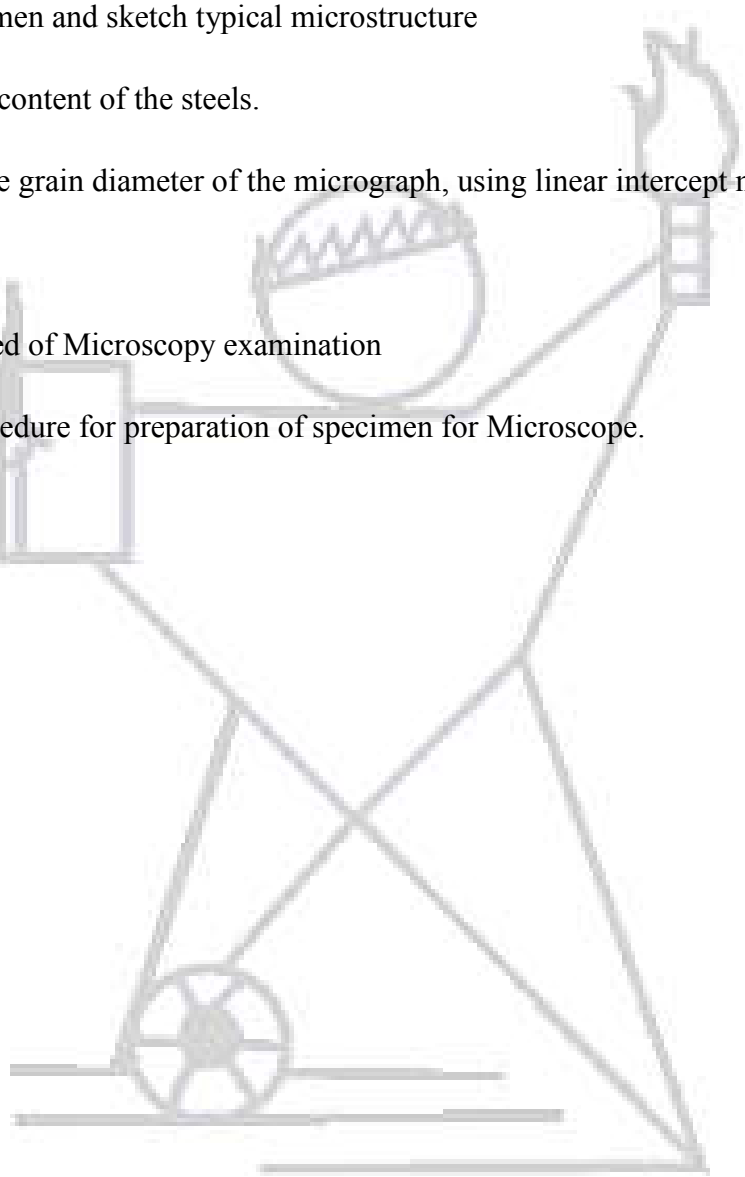
1. Examine each specimen and sketch typical microstructure

2. Estimate the carbon content of the steels.

3. Calculate the average grain diameter of the micrograph, using linear intercept method.

Questions:-

1. What is the Need of Microscopy examination
2. Describe a procedure for preparation of specimen for Microscope.



Experiment No. 3

Objective: - To study hardness as a function of quench rate and investigate the hardenability of steels by Jominy End Quench Apparatus**.**

Apparatus and Material Required:- Jominy End Quench Apparatus, Specimen, Muffle Furnace.

Introduction

The hardenability of a steel is defined as that property which determines the depth and distribution of hardness induced by quenching ftom the austenitic condition. The dependence of hardness upon quenching rate can be understood ftom the time-temperature-transformation characteristics of steel, and, for a particular steel, can be estimated from the T-T-T diagram.

A part may be hardened by quenching into water, oil, or other suitable medium. The surface of the part is cooled rapidly, resulting in high hardness, whereas the interior cools more slowly and is not hardened. Because of the nature of the T-T-T diagram, the hardness does not vary linearly from the outside to the center. Hardenability refers to capacity of hardening (depth) rather than to maximum attainable hardness.

The hardenability of a steel depends on

1.The composition of the steel,

2.The austenitic grain size, and

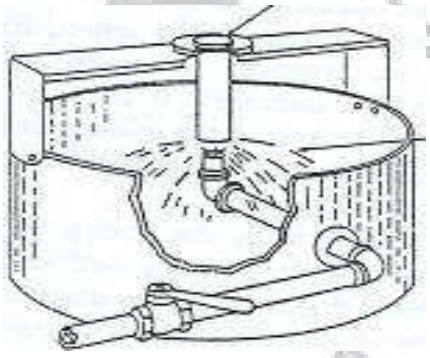
3.The structure of the steel before quenching.

In general, hardenability increases with carbon content and with alloy content. The most important factor influencing the maximum hardness that can be obtained is mass of the metal being quenched. In a small section, the heat is extracted quickly, thus exceeding the critical cooling rate of the specific steel and this part would thus be completely martensitic. The critical cooling rate is that rate of cooling which must be exceeded to prevent formation of nonmartensite products. As section size increases, it becomes increasingly difficult to extract the heat fast enough to exceed the critical cooling rate and thus avoid formation of nonmartensitic products. Hardenability of all steels is directly related to critical cooling rates.

Procedure

Sample of medium carbon steel machined to the shape shown in Fig.2. It is a cylindirical bar with a 25 mm diameter and 100 mm length. The specimen is placed in the furnace at 900 ^{0}C for about $^{1}/_{2}$ hour. The water flow rate is adjusted so that the water column is approximately the distance 50 mm above the end of the pipe, when water is flowing freely.

After the sample has been austenitized, it is removed from the furnace and placed directly into the quenching apparatus. A jet of water is quickly splashed at one end of the specimen. After the entire sample has cooled to room temperature, the scale oxidation is removed; two opposite and flat parallel surfaces are ground along the length of the bar. Rockwell C hardness measurements are then made every 2 mm and these readings are recorded.



Water spray Specimen

Fig. Schematic illustration of the Jominy end-quench test

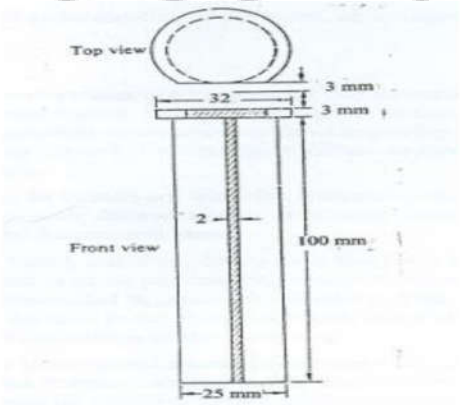


Fig.2 Standard-size sample.

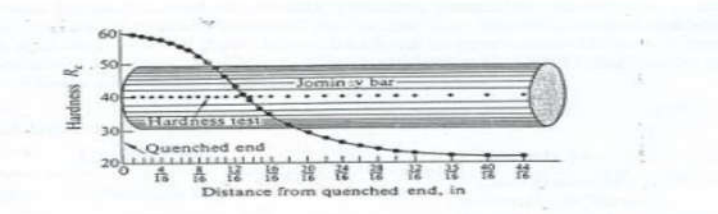


Fig. Schematic illustration of the Jominy end-quench test

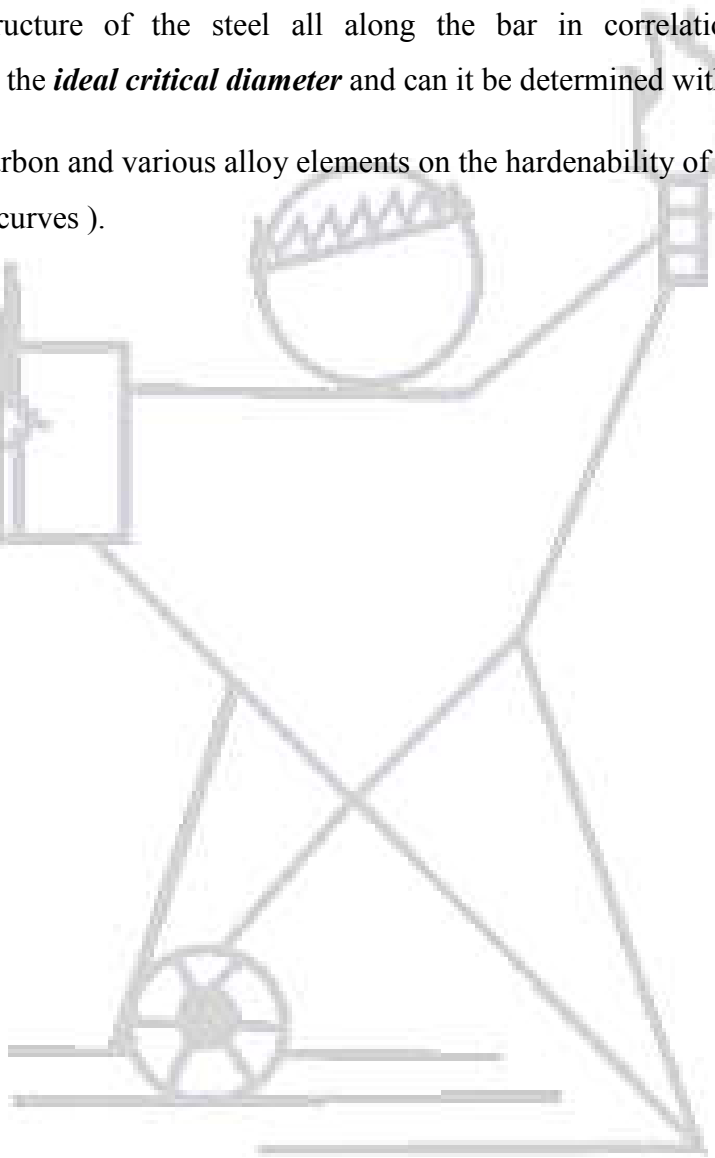
Results: Plot a hardenability curve of Rockwell hardness vs. distance from the quenched end. (Fig)

Questions

1. Evaluate the hardenability of the steel used in this experiment using the plotted hardenability curve.

2.Predict the microstructure of the steel all along the bar in correlation with your hardness measurements. What is the ***ideal critical diameter*** and can it be determined with a Jominy test.

3. How is the role of carbon and various alloy elements on the hardenability of steels (Give examples of different hardenability curves).



Experiment No. 4

Objective:- To gain experience with and understanding of the types, advantages and applications of various NDT methods. To be able to choose the best NDT method for a given part and perform Test on UFD machine.

Apparatus Required:-

1. UFD Machine Flaw detector.

2. UFD Specimen.

Introduction

Up to this point we have learnt various testing methods that somehow destruct the test specimens. These were, tensile testing, hardness testing, etc. In certain applications, the evaluation of engineering materials or structures without impairing their properties is very important, such as the quality control of the products, failure analysis or prevention of the engineered systems in service.

This kind of evaluations can be carried out with Non destructive test (NDT) methods. It is possible to inspect and/or measure the materials or structures without destroying their surface texture, product integrity and future usefulness.

The field of NDT is a very broad, interdisciplinary field that plays a critical role in inspecting that structural component and systems perform their function in a reliable fashion. Certain standards has been also implemented to assure the reliability of the NDT tests and prevent certain errors due to either the fault in the equipment used, the miss-application of the methods or the skill and the knowledge of the inspectors.

Successful NDT tests allow locating and characterizing material conditions and flaws that might otherwise cause planes to crash, reactors to fail, trains to derail, pipelines to burst, and variety of less visible, but equally troubling events. However, these techniques generally require considerable operator skill and interpreting test results accurately may be difficult because the results can be subjective.

These methods can be performed on metals, plastics, ceramics, composites, cermets, and coatings in order to detect cracks, internal voids, surface cavities, delamination, incomplete defective welds and any type of flaw that could lead to premature failure. Commonly used NDT test methods can be seen in table 1. These are universal NDT methods; however, very special tests have been developed for specific applications

Table 1 Commonly used NDT techniques

Technique	Capabilities	Limitations
Visual Inspection	Macroscopic surface flaws	Small flaws are difficult to detect, no subsurface flaws.
Microscopy	Small surface flaws	Not applicable to larger structures; no Smallest defect detectable is 2% of the thickness; radiation protection.
Radiography	Subsurface flaws	No subsurface flaws not for porous materials
Dye penetrate	Surface flaws	No subsurface flaws not for porous materials
Ultrasonic	Subsurface flaws	Material must be good conductor of sound.
Eddy Current	Surface and near surface flaws	Difficult to interpret in some applications; only for metals.
Acoustic emission	Can analyze entire structure	Difficult to interpret, expensive equipments.
Magnetic Particle	Surface / near surface and layer flaws	Limited subsurface capability, only for ferromagnetic materials

Visual inspection:

VI is particularly effective detecting macroscopic flaws, such as poor welds. Many welding flaws are macroscopic: crater cracking, undercutting, slag inclusion, incomplete penetration welds, and the like. Like wise, VI is also suitable for detecting flaws in composite structures and piping of all types. Essentially, visual inspection should be performed the way that one would inspect a new car prior to delivery, etc. Bad welds or joints, missing fasteners or components, poor fits, wrong dimensions, improper surface finish, delaminations in coatings, large cracks, cavities, dents, inadequate size, wrong parts, lack of code approval stamps and similar proofs of testing.

Radiography:

Radiography has an advantage over some of the other processes in that the radiography provides a permanent reference for the internal soundness of the object that is radiographed.

The x-ray emitted from a source has an ability to penetrate metals as a function of the accelerating voltage in the x-ray emitting tube. If a void present in the object being radiographed, more x-rays will pass in that area and the film under the part in turn will have more exposure than in the non-void areas. The sensitivity of x-rays is nominally 2% of the materials thickness. Thus for a piece of steel with a 25mm thickness, the smallest void that could be detected would be 0.5mm in dimension. For this reason, parts are often radiographed in different planes. A thin crack does not show up unless the x-rays ran parallel to the plane 0 the crack. Gamma radiography is identical to x-ray radiography in function. The difference is the source of the penetrating electromagnetic radiation which is a radioactive material such m Co 60. However this method is less popular because of the hazards of handling radioactive materials.

Liquid (Dye) penetrant method:

Liquid penetrant inspection (LPI) is one of the most widely used nondestructive evaluation (NDE) methods. Its popularity can be attributed to two main factors, which are its relative ease of use and its flexibility. The technique is based on the ability of a liquid to be drawn into a "clean" surface breaking flaw by capillary action.

This method is an inexpensive and convenient technique for surface defect inspection. The limitations of the liquid penetrant technique include the inability to inspect subsurface flaws and a loss of resolution on porous materials. Liquid penetrant testing is largely used on nonmagnetic materials for which magnetic particle inspection is not possible.

Materials that are commonly inspected using LPI include the following; metals (aluminum, copper, steel, titanium, etc.), glass, many ceramic materials, rubber, plastics.

Liquid penetrant inspection is used to inspect of flaws that break the surface of the sample. Some of these flaws are listed below; fatigue cracks, quench cracks grinding cracks, overload and impact fractures, porosity, laps seams, pin holes in welds, lack of fusion or braising along the edge of the bond line.

Magnetic particles:

Magnetic particle inspection is one of the simple, fast and traditional nondestructive testing methods widely used because of its convenience and low cost. This method uses magnetic fields and small magnetic particles, such as iron filings to detect flaws in components. The only requirement from an inspect ability standpoint is that the component being inspected must be made of a ferromagnetic material such iron, nickel, cobalt, or some of their alloys, since these materials are materials that can be magnetized to a level that will allow the inspection to be effective. On the other hand, an enormous volume of structural steels used in engineering is magnetic. In its simplest application, an electromagnet yoke is placed on the surface of the part to be examined, a kerosene-iron filling suspension is poured on the surface and the electromagnet is energized. If there is a discontinuity such as a crack or a flaw on the surface of the part, magnetic flux will be broken and a new south and north pole will form at each edge of the discontinuity. Then just like if iron particles are scattered on a cracked magnet, the particles will be attracted to and cluster at the pole ends of the magnet, the iron particles will also be attracted at the edges of the crack behaving poles of the magnet. This cluster of particles is much easier to see than the actual crack and this is the basis for magnetic particle inspection. For the best sensitivity, the lines of magnetic force should be perpendicular to the defect.

Eddy current testing:

Eddy currents are created through a process called electromagnetic induction. When alternating current is applied to the conductor, such as copper wire, a magnetic field develops in and around the conductor. This magnetic field expands as the alternating current rises to maximum and collapses as the current is reduced to zero. If another electrical conductor is brought into the close proximity to this changing magnetic field, current will be induced in this second conductor. These currents are influenced by the nature of the material such as voids, cracks, changes in grain size, as well as physical distance between coil and material. These currents form an impedance on a second coil which is used to as a sensor. In

practice a probe is placed on the surface of the part to be inspected, and electronic equipment monitors the eddy current in the work piece through the same probe. The sensing circuit is a part of the sending coil.

Eddy currents can be used for crack detection, material thickness measurements, coating thickness measurements, conductivity measurements for material identification, heat damage detection, case depth determination, heat treatment monitoring.

Some of the advantages of eddy current inspection include; sensitivity to small cracks and other defects, ability to detect surface and near surface defects, immediate results, portable equipment, suitability for many different applications, minimum part preparation, no necessity to contact the part under inspection, ability to inspect complex shapes and sizes of conductive materials. Some limitation of eddy current inspection; applicability just on conductive materials, necessity for an accessible surface to the probe, skillful and trained personal, possible interference of surface finish and roughness, necessity for reference standards for setup, limited depth of penetration, inability to detect of the flaws lying parallel to the probe coil winding and probe scan direction.

Ultrasonic Inspection:

Ultrasonic Testing (UT) uses a high frequency sound energy to conduct examinations and make measurements. Ultrasonic inspection can be used for flaw detection evaluation, dimensional measurements, material characterization, and more. A typical UT inspection system consists of several functional units, such as the pulser/receiver, transducer, and display devices. A pulser/receiver is an electronic device that can produce high voltage electrical pulse. Driven by the pulser, the transducer of various types and shapes generates high frequency ultrasonic energy operating based on the piezoelectricity technology with using quartz, lithium sulfate, or various ceramics. Most inspections are carried out in the frequency range of 1 to 25MHz. Couplants are used to transmit the ultrasonic waves from the transducer to the test piece; typical couplants are water, oil, glycerin and grease.

The sound energy is introduced and propagates through the materials in the form of waves and reflected from the opposing surface. An internal defect such as crack or void interrupts the waves' propagation and reflects back a portion of the ultrasonic wave. The amplitude of the energy and the time required for return indicate the presence and location of any flaws in the work-piece.

The ultrasonic inspection method has high penetrating power and sensitivity. It can be used from various directions to inspect flaws in large parts, such as rail road wheels pressure vessels and die

blocks. This method requires experienced personnel to properly conduct the inspection and to correctly interpret the results.

As a very useful and versatile NDT method, ultrasonic inspection method has the following advantages; sensitivity to both surface and subsurface discontinuities, superior depth of penetration for flaw detection or measurement, ability to single-sided access for pulse-echo technique, high accuracy in determining reflector position and estimating size and shape, minimal part preparation, instantaneous results with electronic equipment, detailed imaging with automated systems, possibility for other uses such as thickness measurements.

Its limitations; necessity for an accessible surface to transmit ultrasound, extensive skill and training, requirement for a coupling medium to promote transfer of sound energy into test specimen, limits for roughness, shape irregularity, smallness, thickness or not homogeneity, difficulty to inspect of coarse grained materials due to low sound transmission and high signal noise, necessity for the linear defects to be oriented parallel to the sound beam, necessity for reference standards for both equipment calibration, and characterization of flaws.

Acoustic Method:

There are two different kind of acoustic methods: (a) acoustic emission; (b) acoustic impact technique

Acoustic emission:

This technique is typically performed by elastically stressing the part or structure, for example, bending a beam, applying torque to a shaft, or pressurizing a vessel and monitoring the acoustic responses emitted from the material. During the structural changes the material such as plastic deformation, crack initiation, and propagation, phase transformation, abrupt reorientation of grain boundaries, bubble formation during boiling in cavitation, friction and wear of sliding interfaces, are the source of acoustic signals. Acoustic emissions are detected with sensors consisting of piezoelectric ceramic elements. This method is particularly effective for continuous surveillance of load-bearing structures.

Acoustic impact technique:

This technique consists of tapping the surface of an object and listening to and analyzing the signals to detect discontinuities and flaws. The principle is basically the same as when one taps walls, desktops or countertops in various locations with a finger or a hammer and listens to the sound emitted. Vitrified grinding wheels are tested in a similar manner to detect cracks in the wheel that may not be visible to

the naked eye. This technique is easy to perform and can be instrumented and automated. However, the results depend on the geometry and mass of the part so a reference standard is necessary for identifying flaws.

Liquid penetrant method:

In this method the surfaces to be inspected should be free from any coatings, paint, grease, dirt, dust, etc.; therefore, should be cleaned with an appropriate way. Special care should be taken not to give additional damage to the surface to be inspected during the cleaning process. Otherwise, the original nature of surface could be disturbed and the results could be erroneous with the additional interferences of the surface features formed during the cleaning process.

Surface cleaning can be performed with alcohol. Special chemicals like cleaner-remover can also be applied if needed. In the experiment, only cleaner-remover will be sufficient. Subsequent to surface cleaning, the surface is let to dry for 2 minutes.

Commercially available cans of liquid penetrant dyes with different colors are used to reveal the surface defects.

Steps used in the experiment:

1.Clean the surface with alcohol and let surface dry for 5 min.

2.Apply the liquid penetrant spray (red can) to the surface and brush for further penetration. Then, wait for 20 min.

3.Wipe the surface with a clean textile and subsequently apply remover spray (blue can) to remove excess residues on the surface and wait for a few min.

4.Apply the developer spray (yellow can) at a distance of about 30cm from the surface. The developer will absorb the penetrant that infiltrated to the surface features such as cracks, splits, etc., and then reacted with it to form a geometric shape which is the negative of the geometry of the surface features from which the penetrant is sucked.

5.The polymerized material may be collected on a sticky paper for future evaluation and related documentation, if needed.

Magnetic particle:

In this experiment, commercially available magnetic powder manufactured for NDT inspection will be used. A strong U shape magnet will be used to provide the necessary magnetic field at the inspected area.

The following steps are applied during the experiment;

1.The surface of the specimen will be roughly cleaned wiping with a piece of textile.

2.The fluorescent magnetic spray will be applied on the surface being inspected.

3.Magnetic field will be applied with a strong magnet to the location of interest.

4.The spots where the fluorescent magnetic particles accumulated will be inspected under UV light.

Eddy current inspection:

For this experiment, Magnefest ED-51 0 type unit will be used. A pencil type prop will be used for the inspections. The inspection is performed with 2 MHz frequency and at the related calibration settings. The test blocks were previously prepared for this experiment. Any coatings or paints on the surface of inspected specimens should be treated with special procedures.

The following steps should be applied during the experiment:

l. Inspection area should be clean, smooth, free from any irregular or uneven paint, dirt, grease, etc.

2.There shouldn't be any visible damage or discontinuity.

3.During the inspection procedure the probe will be positioned near the inspection area, on the compensation point and lift off and zero will be adjusted if necessary.

4.The inspection will be carried out by using probe scans. The probe tip will be always at a right angle the inspection surface.

5.Any indication with indicator deflection to the right should be evaluated. All evaluated indications should be measured.

After this procedure, all evaluated indications with indicator deflections, will be classified as cracks and be recorded.

Ultrasonic inspection:

For this experiment,USM-2 type ultrasonic unit will be used. The props used supports to work at frequency of 5 MHz. Echo techniques will be employed to find the cracks.

Instrument will be tuned to a frequency of 5 MHz. An appropriate couplant used should not cause corrosion or other damage. During the inspection the calibration will be done on the reference standard, if needed. Two different test blocks will be employed in this test, sufficient amount of couplant will be applied to the transducer scan areas on the forward and after sides of the support fitting. The display will be monitored for crack indications. A crack signal will be similar to the following:

The following steps should be applied during the experiment:

1. The couplant should be applied on the inspected area.

2. For the circular test specimen, the prop will be placed in the corresponding space in the supporting fitting tool. Enough couplant should be used between the probe and tool.

3. For the flat specimen, no tool is needed, couplant only applied between the inspected surface and the probe.

4. Special attention should be paid on the location where possible cracks exist.

5. A discontinuity like a crack produces a peak on the screen.

6. Attention should also be given to the movement of the possible peak caused by the cracks on the specimen.

Questions:-

1. Types of testing perform on a material.
2. Explain any two NDT techniques.

Experiment No. 5

Objective: - To determine Carbon and Sulphur contents in iron and steel by Strohlein's Apparatus.

Apparatus and Material Required:-

Strohlein's apparatus, Sulphuric acid, KOH solution, Indicators, reagents, oxygen cylinder, combustion furnace, beaker, stirrer etc.

Introduction: The determination of Carbon and Sulphur contents in iron and steel has become an absolute necessity for all iron processing plants, foundries etc. There is a substantial saving of time, as in a short time, both Carbon and Sulphur can be determined in one action. The dual determination is excellently suitable for routine analysis.

Description of the Method:- Steel or iron chips are heated in a stream of oxygen to about 1250°C which converts carbon to carbon dioxide and Sulphur to Sulphur dioxide. The combined gas is passed through a neutral solution of hydrogen peroxide of known concentration. The Sulphur dioxide dissolves in hydrogen peroxide forming Sulphuric acid which can be titrated with caustic soda solution to determine percentage of Sulphur. The carbon dioxide of the combined gases from which the Sulphur has been removed is taken in a burette. From here the gas is taken into an absorption vessel containing KOH to absorb carbon dioxide. The reduction in volume of the total gas indicates the total volume of carbon dioxide which is directly calibrated in percentage of carbon.

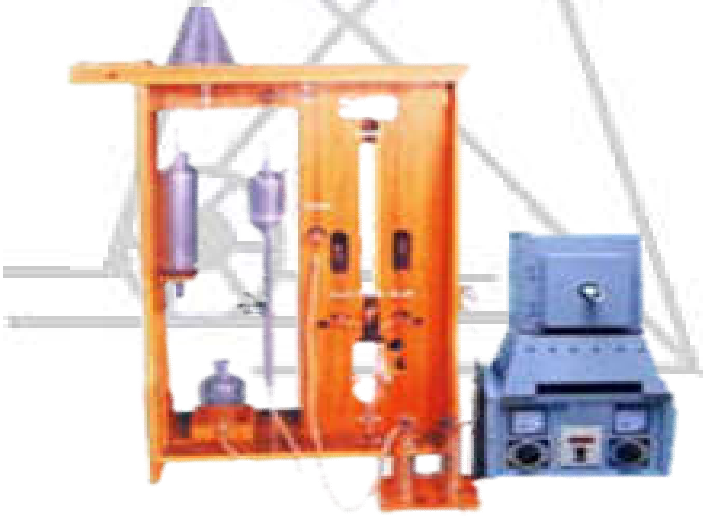


Fig. Strohlein's Apparatus

Principal of operation: Steel and iron chips are heated in a stream of oxygen to about 1300^{o}C which converts carbon to carbon dioxide and Sulphur to Sulphur dioxide. The combined gases are passed through a neutral solution of hydrogen peroxide of known concentration. The Sulphur dioxide dissolves in hydrogen peroxide forming Sulphuric acid which is titrated with caustic soda solution of known strength to determine the percentage of Sulphur. The carbon dioxide of the combined gases from which the Sulphur dioxide has been removed is taken in a burette. From here the gas is taken into an absorption vessel containing KOH to absorb carbon dioxide. The reduction in volume of the total gas equals the total volume of carbon dioxide, knowledge of which then gives the amount of carbon. The scale is calibrated in term of carbon percentage.

Requirement for the Apparatus

- **Oxygen Supply**: 99.5% pure oxygen.
- **Pressure Reducing Device**: This is a fine adjusting valve with cylinder content gauge. The complete unit fixes directly on the oxygen cylinder. The connection from valve to oxygen purifier is connected through rubber tubing.
- **Oxygen Purifier**: It consists of a U tube and two gas bubblers fitted on wooden case containing concentrated Sulphuric acid and crystalline calcium chloride. Drawing shows complete arrangement, of this train, marked with all chemicals required.
- **Combustion furnace**: This is designed as Electric Furnace with two silicon carbide rods, which serve as heaters. The rods are placed in a round muffle tube above the porcelain combustion tube, which is inserted in the middle of the Furnace. The space between the muffle and the outer body of the furnace is well packed with insulating material.

The furnace is supplied with a platinum/platinum rhodium thermocouple. There is an opening provided in the furnace to insert the thermocouple. Thermocouple leads are connected to temperature indicator. Leads coming out from the furnace are connected to the control unit terminals, marked voltage.

- **Control Unit**: Control Unit consists of a variac, current and voltage meters. By adjusting the variac control knob, the temperature of the furnace can be adjusted as desired. Silicon carbide rods are connected in series to prevent simultaneous damage to all two rods due to excessive instantaneous current. Never supply more than 10 amps to silicon carbide rods.

200 volts A.C. and 20 amps mains supply is required to operate the control unit.

Operating Instructions for Combustion Furnace And Control Unit

The electric furnace is designed with two carbide rods which serve as heaters. Two silicon carbide rods, clamps and connectors are packed separately.

The rods are pushed through the two openings provided in the end gaps until the two ends of the rods towel out to the same length on both sides.

To avoid loss of heat, the openings should be scaled with asbestos threads. The connecting clamps should be attached on the metalized ends of the heating rods. The heating rods must be connected in series by the connectors supplied.

Temperature measuring device: In the centre of the furnace body, opening is provided for the thermocouple. The thermocouple is provided with leads to be connected to the two terminals of the Pyrometer.

Control Unit: Described above.

To be given special attention:

- The maximum temperature of the furnace 1300°/140Q°C should be maintained only for short duration, shortly before this temperature is attained, it is advisable to switch off the furnace or in the case of continuous service, the voltage must be decreased**.**
- Never give more than 10 amps to silicon carbide rods**.**
- Silicon carbide rods must be connected in series.
- When first operating the furnace (when received new) the temperature should be increased slowly Attainment of maximum temperature should be done in about 8 to 10 hours.

Reagents Required

All reagents must be of reagent grade.

1. Prepare 5% Hydrogen Peroxide solution for Sulphur vessel for the absorption of Sulphur dioxide.
2. Use Methyl Red as indicator for titration.

3. Prepare N/40 solution of NaoH for Sulphur titration. Dissolve 5 gm of NaoH in 5 liters of distilled water.

4. Prepare Potassium Hydroxide solution for CO_2 absorption. Dissolve 350gms of potassium hydroxide in 750 ml of distilled water. Solution should be filtered.

5. Confining liquid for leveling bottle should be salt solution acidulated by a little Sulphuric (2.98 by volume) and coloured with a few drops Methyl Orange**.**

For carbon determination apparatus reagents under 4 and 5 only are required.

Description of Various Parts Of The Apparatus

1. **Wooden Cabinet**: All glass parts of the apparatus are mounted on this cabinet. All fixing clamps and screws are packed separately.

2. **Carbon Burette**: It is triple jacket tube with provision for Water jacketing with one inlet. It has a internal graduation scale calibrated directly in percentage of carbon with 1.5% or 4.5% carbon or as ordered. It has also provision for fixing a thermometer to measure the internal temperature. As shown in Drawing, the upper end which has a unidirectional float valve should be connected with 3-way 'T' type stop cock 'T' by rubber tubing. The lower end of this burette is connected to the leveling bottle by a 1½ meter long rubber tubing supplied with the apparatus.

3. **Leveling Bottle**: This bottle has a capacity of 800 ml for confining liquid and is placed on a stand. It is filled with such an amount of confining liquid that the level of the liquid (by a barometric height) is situated in the lower part of the graduated tube. In this position it is thus able to-fix-point on the internally graduated scale. Here great caution must be observed that the tube which links the burette to the leveling vessel does not contain any air bubbles.

4. **Absorption Vessel**: It is filled with potassium hydroxide solution to absorb CO_2 of the gases. The solution is prepared in the following way.

    a) Fill the limb 'B' of the absorption upto the neck.

    b) Remove all the air from the carbon burette by raising the leveling bottle such that the confining liquid completely fills it and the unidirectional valve closes. During this process the stop cock ‘L’ should be open to atmosphere and stop cock ‘T' should make connection with ‘L’.

c) Connect stop cock 'T' with tee absorption vessel.

d) Lower the leveling bottle till KOH solution fills completely the limb A of the absorption vessel and upper unidirectional valve closes expelling all air out of the limb.

e) When the limb A is completely filled with unidirectional valve closed, the level of KOH in the limb B should be about 1 /3rd of the total capacity. Use more KOH solution if required and repeat the above procedure

f) Move the stop cock 'T' to make connection with 'L'.

5. **3-Way T stop Cock**: As shown in the drawing it connects L stop cock carbon burette and absorption vessel.

6. **L-Glass Tube with Stop Cock**: This has two way connections. In one way it opens to atmosphere and in other way it makes connection with the 3-way T stop cock to pass through to carbon burette.

7. **Sulphur Titration Burette**: It is a micro-burette subdivided into 2/100 in millitres and contains 4 ml. When applying an accurate N/40 NaoH, 1 ml. corresponds to 0.0004 gm Sulphur. The burette is connected with the reservoir for automatically filling the burette.

8. **Titration vessel and Knee**: This is graduated upto 100 ml· It can be emptied from below with two way cock. This vessel connected with a glass knee. A glass capillary tube drops deeply into the vessel through which the combustion gases bubble.

Filter must be changed after it has been used in about 10 estimations in the case of grey cast iron or about 40 in the case of steel.

9. **Observation Glass Tube**: This tube is adapted to the inlet position of the furnace where the oxygen enters into the porcelain tube, through which combustion can be observed.

10. **Steel Scoop**: For inserting the boats with sample for combustion and for removing the combustion boats from the furnace.

Procedure:

1. Carbon Determination

First keeping the leveling bottle on the movable stand, adjust the liquid level to stand at zero point on the burette scale. This can be done by adjusting the height of the leveling bottle.

Three way stop cock ‘T' is connected to ‘L' stop cock and 'L' stop cock is opened to atmosphere. A leveling bottle is raised to completely fill the carbon burette till the upper unidirectional valve closes, thus expelling all the air of the carbon burette. The stop cock T is closed; the stop cock L which was connected to atmosphere is connected to T.

The boat which contains the specimen is pushed into the middle of the heating region the rubber stopper with the observation glass tube is placed in the porcelain tube, so that the conveyanee of oxygen can commence. Simultaneously stop cock 'T is connected to 'L'. After a correct and well timed heating, the chips burn and throw out sparks, whereby the level of the confining liquid temporarily stops to sink, this is due to total absorption brought about by the high demand of the oxygen. This absorption effect is to be eventually compensated by increasing the flow of the oxygen it must now; however, (especially in the case of higher test samples i.e. 1 gm) surpass a certain measure, while an intense burning will produce a sputtering of slag particles in the combustion tube. In any case after being performed a few times the proper rate of the flow of oxygen should be adopted. The flow should be adjusted such that the combustion completes when the carbon burette is one third filled with the combustion gases.

During period of rewashing it is possible to weaken the oxygen current a little. As soon as the burette filled to the end of the tube with the combustion gases, the stop cock 'L' is brought to atmosphere position by which oxygen is able to flow freely. The procedure should be manipulated that the liquid level comes to zero point and if does not, the ‘L’ stop cock should be turned momentarily to connect the carbon burette comes through stop cock ‘T’ to atmosphere.

The volume of the combustion gases is now in contact with the open air, this means to say that it is situated under the barometric height, so that zero point is automatically positioned, (it can eventually be adjusted, by a slight displacement of the scale). Following this and corresponding to the turning of the stop cock ‘T’ the burette is connected to the absorption vessel. The temperature in the burette is than

noted, and the combustion gases are compressed into the absorption vessel, by lifting the leveling vessel, until the confining liquid closes the return valve in the burette.

By lifting and lowering the leveling vessel, the conveyance of the combustion gases through the potassium hydroxide solution is repeated. After this, the gases are conducted back to the burette, this is performed by lowering the leveling vessel, and then by closing the stop cock. The confined volume of gas residue is compressed a little by lifting the leveling vessel, then the carbon contents are read off, by an equally high liquid level in the graduated tube and in the applied leveling vessel and consequently by a barometric height.

Now stop cock 'T" is opened towards 'L' the leveling vessel is lifted up, and the carbon burette is once again filled with confining liquid up to the return valve, till unidirectional valve closes so that it is ready for next determination.

2. Sulphur Determination

In the mean time, the So_2 gas is collected into Sulphur vessel 'M' which contains 5% hydrogen peroxide solution. The Sulphur dioxide is absorbed by hydrogen peroxide forming Sulphuric acid. The stopper valve is lifted and the liquid is titrated to the equivalent point, with a continuous supply of oxygen, against N/40 NaoH solution, using methyl red as the indicator. During the titration, stop the oxygen supply several times so that reaction liquid in S. V. M is able to rinse out residue of acid which could have remained in the supply tube. After the oxygen has been fed once again the titration should be stopped when the end point is attained. The precision Sulphur burette is subdivided into 2/100millilitres and contains 4ml. When applying an accurate N/40 NaoH, 1ml. corresponds to 0.0004gms of Sulphur in the gram or .04% Sulphur.

Precautions:

1. Since hydrogen peroxide contains certain impurities, a blank titration of hydrogen peroxide against sodium hydroxide should be taken and the reading should be deducted from the original reading of the Sulphur content.

2. For accurate work very pure oxygen is required. The purity of the gas must be re-tested by means of a blind test. It must on no account contain acid particles.

3. Unknown materials should be analyzed thrice where as In the case of specimen of running production one determination each will prove to be sufficient. In the beginning of the day's work, the equipment must be checked by standard samples.

4. The glass tube parts which are adopted and which are linked by a rubber tube, should always be connected glass to glass. The course from the porcelain tube to the Sulphur titration vessel should be as small as possible.

5. For the estimation of Carbon in Iron and steel the furnace temperature should be between 1300^{o}C to 1350°C.

6. Weighing of the samples should be done very accurately. In the case of ordinary dimensions of the porcelain boats and tubes, test samples from 0.2 to 0.5 gm. have proved to be most suitable. Higher test samples say 1 gm. would lead to an increased wear of the porcelain tubes which is due to the intensive heat transformation, especially in cases where larger determinations are to be performed.

7. When possible, the specimens having rich and poor Sulphur contents must be burnt in separate combustion tubes. A porcelain tuba in which grey Cast Iron with 0.01%S is repeatedly burned cannot be used any more for the determination of less than 0.001% of Sulphur in steels.

8. If the quality of the combustion boat is in doubt, it should be preheated at temperature of 1100°c before using. A blind test should be taken for few boats and the average reading of carbon or Sulphur should be deducted from the original reading.

9. All chemicals should be prepared correctly.

10. Some accelerators can be used to accelerate the oxidation, such as lead chromate, a mixture of copper oxide and zinc oxide (1:1) etc.

11. Always keep the Sulphur titration vessel half filled with hydrogen peroxide solution even when Sulphur determination is not required and only Carbon content is to be estimated. The issuing gas bubbles through the hydrogen peroxide solution and cools the gas. This is important and necessary as no cooling condenser is used in a combined apparatus. Once filled no necessity of changing H_2O_2 till Sulphur estimation is required.

12. For higher accuracy for Sulphur determination, the NaoH and H_2O_2 can be taken in a more diluted form. Quantity of Hydrogen Peroxide solution taken in the titration vessel depends upon the concentration of the hydrogen peroxide solution and the amount of the test sample. After performing few tests the proper amount can be estimated. Approximately it should be more than 50 ml.

Optional accessories for Sulphur determination:

These are supplied if ordered, and useful only when many Sulphur estimations must be done every day. The accessories consist of two automatic pipettes, 10ml for Hydrogen peroxide solution and 15ml for distilled water, Proper opening are provided to install them on the wooden frame as shown in the drawing. Three glass reservoirs of 2 litres capacities are supplied for NaoH, distilled water and for Hydrogen peroxide solution. Pipettes are connected to the reservoirs by tubing supplied. Hydrogen peroxide is taken from 10mI. Pipette and distilled water from the 15 ml. pipette to dilute it, into the titration vessel. This saves time and the equipment is immediately ready for the next determination.

Only one or two estimation in a day will not find these accessories useful, Hydrogen peroxide solution will go bad if left for a long time unused. It is always recommended to prepare fresh solution if one or two estimations in a day are done.

Questions:-

Q.1 what are the other methods to determine carbon and sulphur content in ferrous materials

Q.2 Write the changes of properties varying the percentage of various constituents in ferrous materials.

Experiment No. 6

Objective:- Study of Annealing processes of heat treatment and its effect on microstructure and Mechanical Properties**.**

In general, heat treatment can be defined as an operation, or the combination of operations that involve heating and cooling of a metal in solid phase to obtain certain required properties.

The ferrous materials can be heated to above transformation temperature and can be heat – treated to obtain different structure.

The different heat treatment processes are based on heating the material to certain temperature and employing different cooling rates.

In this process, heating temperature and rate of cooling adopted plays an important role.

The different processes are:

Annealing

Stress-relief annealing.

Process annealing.

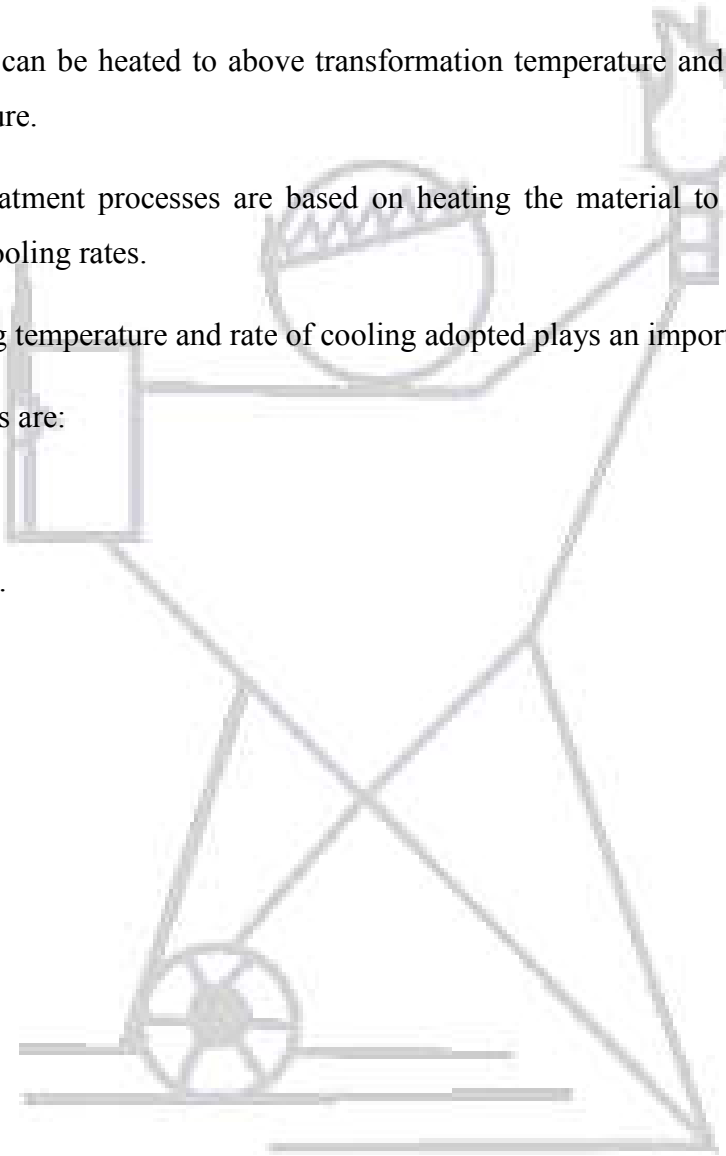
Spheroidising.

Full annealing.

Normalizing

Hardening

Tempering



Annealing:

Annealing primarily is the process of *heating* a metal which is in a metastable or distorted structural state, to a temperature which will remove the instability or distortion and then *cooling* it to the room temperature so that the structure is stable and/or strain free.

Purpose of Annealing:

1.Removal of residual stress.

2.Refining and homogenizing the structure and to give a coarse pearlite structure.

3.Improving machinability.

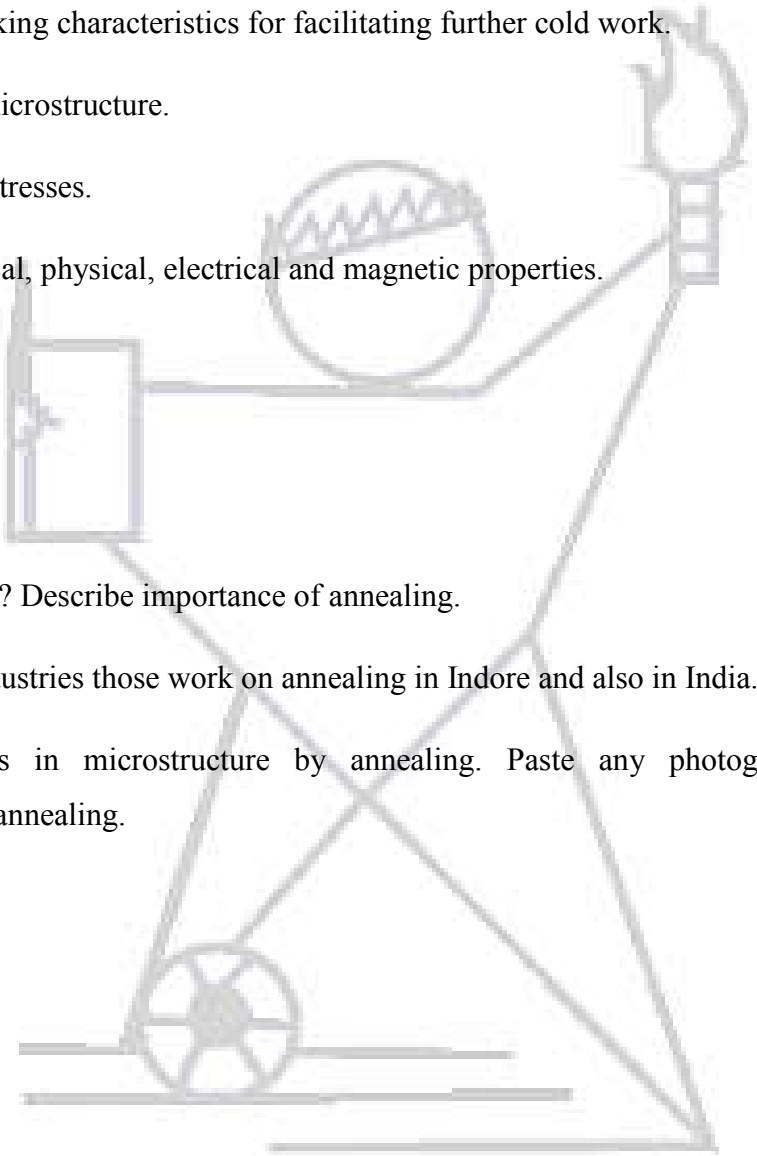
4.Improving cold working characteristics for facilitating further cold work.

5.Producing desired microstructure.

6.Removing residual stresses.

7.Improving mechanical, physical, electrical and magnetic properties.

8.Reducing hardness

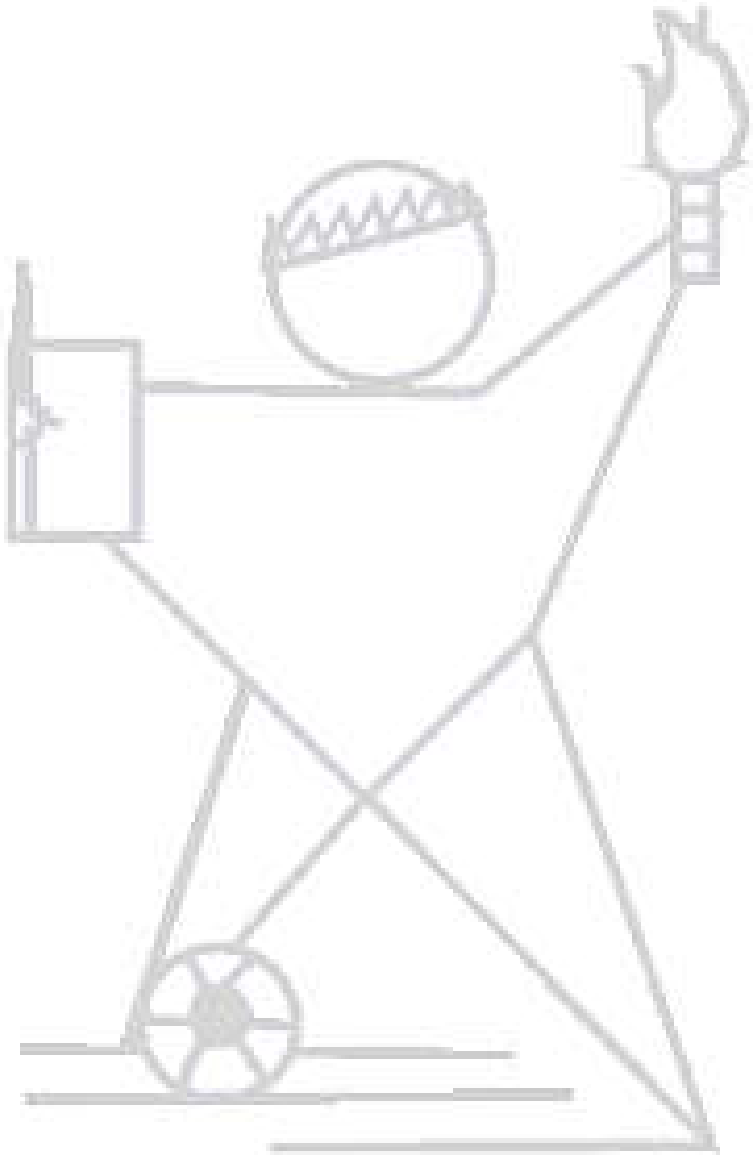


Questions:-

Q.1 What is annealing? Describe importance of annealing.

Q.2 Write name of industries those work on annealing in Indore and also in India.

Q.3 Explain changes in microstructure by annealing. Paste any photograph of changes of microstructure due to annealing.



Normalizing:

This process involves heating the metal above the transformation temperature up to 900° C and cooling from that temperature adopting the required rate of cooling. This process involves:

1.Heating the metal to around 900º C so that the metal transforms completely into austenite.

2.Holding at that temperature for some times (3minutes / mm of thickness)

3.Cooling at a rate of 80° C to 90° C per hour up to 700°C

4.Then air – cooled from 700° C to room temperature.

Purpose of Normalizing:

1.Refining the grain structure and giving a fine pearlite structure.

2.Producing a uniform structure.

3.Achieving the required strength and ductility in a steel that is too soft and ductile for machining.

4.Improving structures in welds.

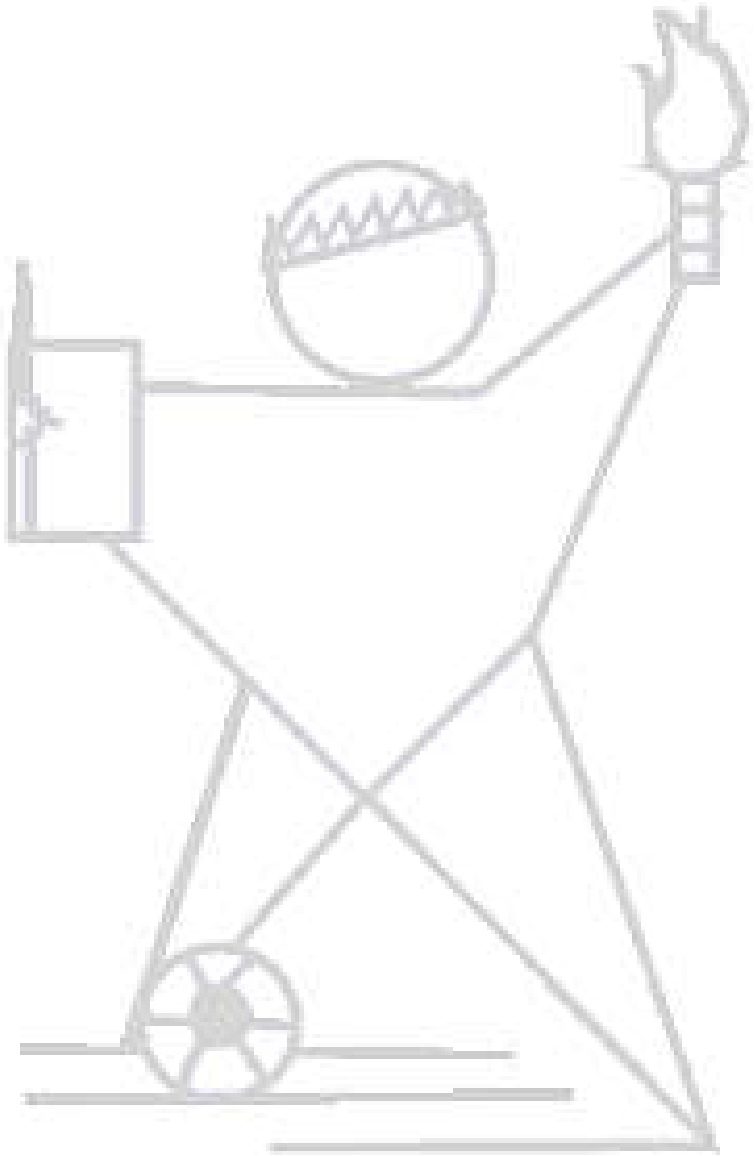
5.In general, improving engineering properties of steels.

Questions

Q.1 what is normalizing? Describe importance of normalizing.

Q.2 Write name of industries who works on Normalizing in Indore and also in India.

Q.3Explain changes in microstructure by Normalizing. Paste any photograph changes of microstructure due to Normalizing.



Hardening: (By Quenching)

Hardening is performed on metals to obtain desired hardness and structure. It involves:

1.Heating the metal above transformation temperature, around 900°C

2.Holding at that temperature for 15 to 30 minutes per 25mm of cross-section.

3.Quenching it immediately in a suitable cold medium (brine solution,Water, oil etc.)

4.Hardness obtained will depend upon the Composition of the material, nature and properties of quenching medium and quenching temperature.

Properties obtained by hardening are:

1.Desired hardness can be obtained.

2.Strength of material is increased.

3.Wear resistance is increased.

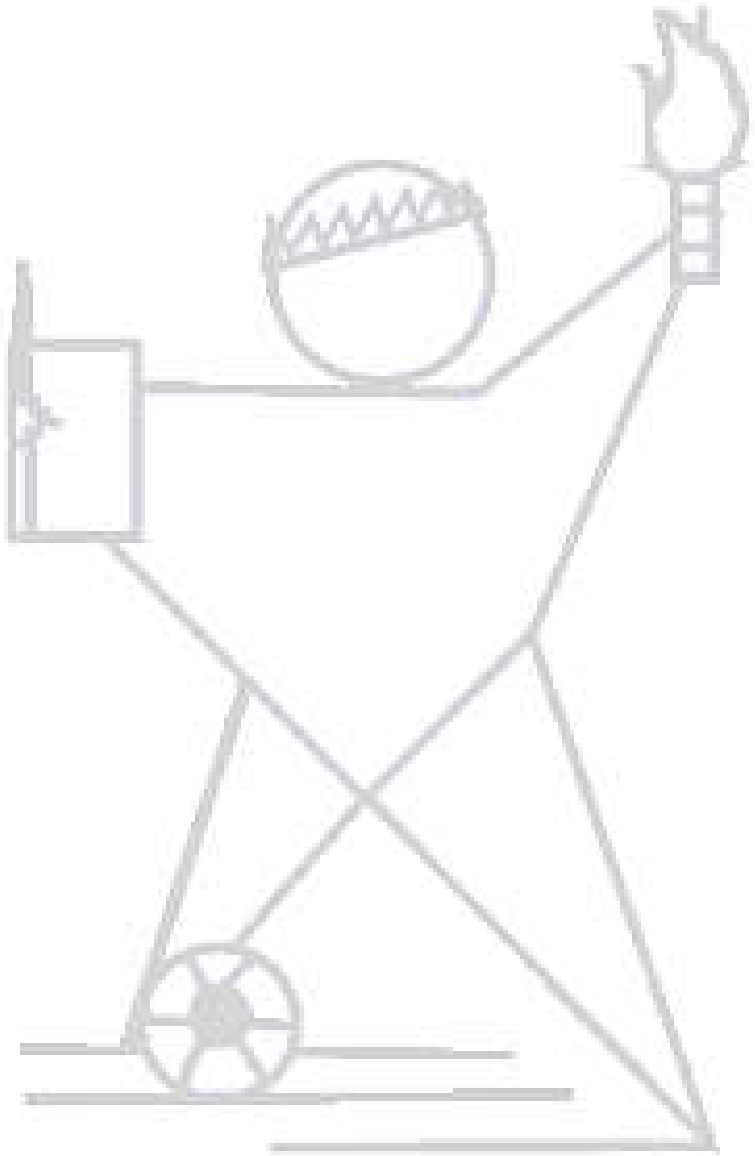
4.Martensite structure is obtained.

Questions

Q.1 What is hardening? Describe importance of hardening.

Q.2 Write name of industries who works on hardening in Indore and also in India.

Q.3 Explain changes in microstructure by hardening. Paste any photograph changes of microstructure due to hardening



Tempering:

Hardening of metal produces Martensite structure with some retained austenite. The martensite structure makes the metal very hard and brittle. The retained austenite is unstable and it will change with time. This transformation of retained austenite even at room temperature leads to distortion of metal. Due to these factors the hardened metal cannot be used as it is. Hence tempering is carried out on the metals.

Tempering treatment involves:

Heating the metal just above Martensite structure temperature (50 ^{O} C), Holding it at that temperature for some time and then cooling either rapidly or slowly. The purpose of tempering is to remove brittleness and improve ductility in the material.

The Properties obtained after Tempering are:

1.Improvement in ductility and toughness.

2.Slight reduction in hardness.

3.Increase in tensile strength.

4.Reduction in internal stress.

Questions:-

Q.1 What is tempering? Describe importance of tempering.

Q.2 Write name of industries who works on Tempering in Indore and also in India.

Q.3 Explain changes in microstructure by tempering. Paste a photograph changes of microstructure due to tempering.