DEPARTMENT OF MECHANICAL ENGINEERING

17MECC84 - METALLURGY LAB (UG)

LAB MANUAL

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HOD/MECH

METALLURGY LABORATORY

SAFETY RULES

ABC of Safety : Always Be Careful

Do's:

- Laboratory is not a place to play. Avoid distractions while working with machines.
- Always wear tight fitting clothes and thick leather shoes.
- Report immediately about the injury caused; if necessary use the first aid box available in laboratory.
- Report immediately about the damage caused to the machines to the Instructor.
- Before operating a machine, learn completely the working procedure of it.
- Handle your materials and loads ergonomically.
- Handle the Etchants carefully as they are hazardous Chemicals.
- Take care of your fingers while polishing the specimen.

Don'ts:

- Don't touch the polished and etched surface. Avoid scratches after etching.
- Don't wipe the etched surface.
- Don't interchange the specimen positions. Store the specimen in their respective place.
- Don't keep bare hand into the furnace. Use tongs and wear gloves.
- Don't wear watches or bracelets while working in machines.
- Don't carry tools in pockets.
- Don't touch the lens of Microscopes.
- Don't remove any guards or parts of any machine.

1. INTRODUCTION TO METALLOGRAPHY

AIM:

To know about metallography and to study the various tools used in the relevant field.

METALLURGY/METALLOGRAPHY:

Metallurgy is the science and technology of metals. As an art it has been practiced since ancient times. The art of smelting, refining and shaping metals was highly developed by both the Egyptyians and the Chineese. Knowledge of dealing with metals was generally passed directly from master to apprentice in the middle ages, leading to an aura of superstitions surrounding many of the processes.

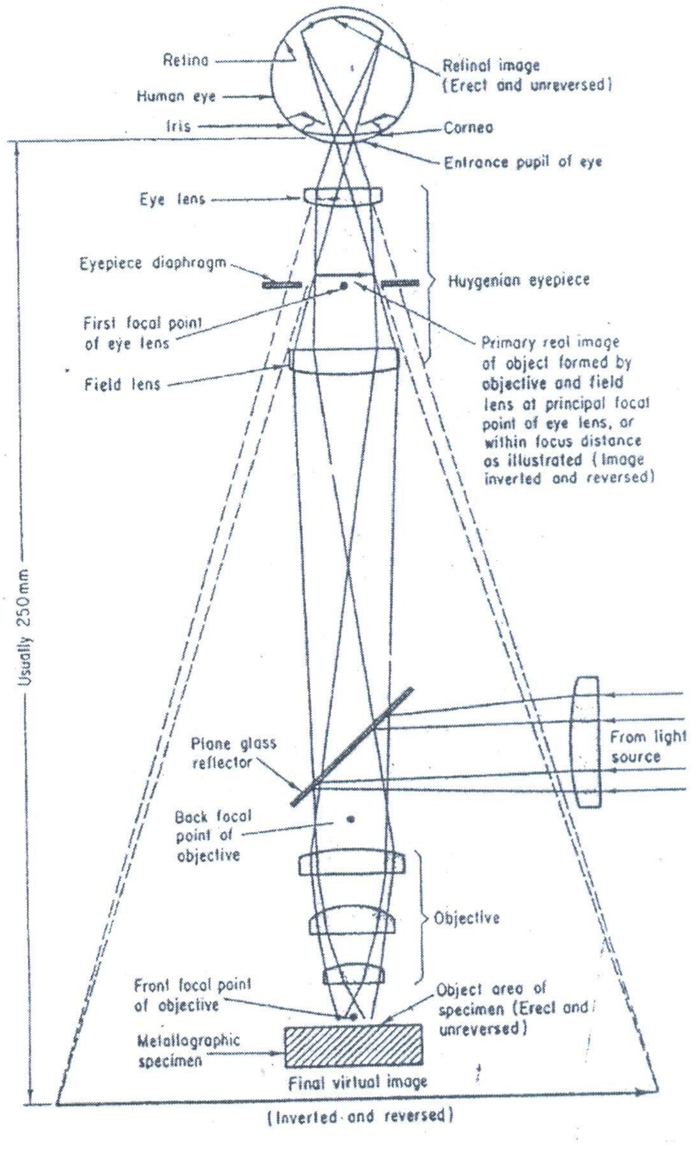
Metallurgy has become an important subject in the modern technology. Years ago, the great majority of steel parts were made of cheap low carbon steel that would machine and fabricate easily. Heat treatment was reserved largely for tools. Designers were unable to account for structural inhomogenity, surface defects etc. and it was considered good practice to use large factors of safety. Consequently, machines were much heavier than they should have been and the weight was considered a mark of quality. This attitude has persisted to some extent to the present time but has been discouraged under the leadership of the aircraft and automotive industries. They have strongly emphasized the importance of strength - weight ratio in good design and this has led to the development of new high strength, light weight alloys.

New technical applications and operating requirements pushed to higher levels have created a continued need for the development of new alloys. Metallurgy is really not an independent science since many of its fundamental concepts are derived from physics, chemistry, and crystallography. The metallurgical field may be divided into two large groups such as Extractive metallurgy and Physical metallurgy.

The science of obtaining metals from their ores, including mining, concentration, extraction and refining metals & alloys is Extractive Metallurgy.

The science concerned with the physical and mechanical characteristics of metals and alloys is termed as Physical Metallurgy. This field studies the properties of metals and alloys as affected by their chemical compositions, mechanical and heat treatments.

PRINCIPLE OF METALLURGICAL MICROSCOPE



TOOLS OF METALLURGIST:

Highly sophisticated and calibrated tools are available in the field of metallurgy. Metal expansion thermometers, liquid expansion thermometers, vapour expansion thermometers, resistance thermometer, thermo electric pyrometer, optical pyrometer, thermo electric materials, radiation pyrometer, metallurgical microscopes are some among them.

Let us study the construction and working principle of ***Metallurgical Microscope*** in detail. The microscope is by far the most important tool of the metallurgist from both the scientific and technical stand points. It is possible to determine grain size, shape and distribution of various phases and inclusions which have a great effect on the mechanical properties of the metal. The microstructure will reveal the mechanical and thermal treatment of the metal and it may be possible to predict its expected behavior under a given set of conditions. A microscope is employed to study the microstructure of material since the object is opaque it is viewed under reflected light.

In comparison with the biological type, the metallurgical microscope differs in manner by which the specimen is illuminated. Since the object is opaque, the sample must be illuminated by reflected light. As shown in figure, a horizontal beam of light from some light source is reflected, by means of a plane-glass reflector, downward through the microscope objective onto the surface of the specimen. Some of this incident light reflected from the specimen surface will be magnified in passing through the lower lens system, the objective and will continue upward through the plane-glass reflector and be magnified again by the upper lens system, the eye piece. The initial magnifying power of the objective and the eye piece is usually engraved on the lens mount. When a particular combination of objective and eyepiece is used at the proper tube length, the total magnification is equal to the product of magnifications of objective and eyepiece. It is possible to mount a camera bellows above the eye piece and use the table type microscope for photomicrography.

The maximum magnification obtained with the optical microscope is about 2000x. The principle illumination is the wave length of visible light, which limits the resolution of fine detail in the metallographic specimen. The magnification may be extended somewhat by the use of shorter wave length radiation, such as ultraviolet radiation, but the sample preparation would include more techniques. The greatest advance in resolving power was obtained by the electron microscope. Under certain circumstances, high velocity electrons behave like light of very short wave length. The electron beam has associated with it a wavelength nearly 100000 times smaller than the wave length of visible light, thus increasing the resolving power tremendously.

The lenses of the electron microscope are the powerful magnetic fields of the coils and the image is brought into focus by changing the field strength of the coils while the coils remain in a fixed position. In optical microscope the image is brought into focus by changing the lens spacing. Although the principle of electron and optical microscopes are same, the former is large. The electron microscope is much larger because of the highly regulated power supplies that are needed to produce and control the electron beam. The entire system must be kept pumped to a high vacuum since air would interfere with the motion of the electrons.

RESULT:

Thus the metallography and the various tools used in the relevant field were studied.

2. PREPARATION OF METALLOGRAPHIC SPECIMEN

AIM:

To prepare a specimen for microscopic examination.

TOOLS REQUIRED:

Linisher – Polisher, Different grades of emery sheets (Rough & Fine), Disc Polisher, Metallurgical Microscopes.

PROCEDURE:

The specimen preparation consists of following stages:

i) Rough grinding
ii) Intermediate Polishing
iii) Fine Polishing
iv) Etching

(i) Rough grinding:

It is first necessary for specimen to obtain a reasonable flat surface. This is achieved by using a motor driven energy belt called Linisher-Polisher. The specimen should be kept over the moving belt which will abrade the specimen and make the surface flat. In all grinding and polishing operations, the specimen should be moved perpendicular the existing scratches, so that the deeper scratches will be replaced to a shallower one. This operation is done until the specimen is smooth, free from rust, burs, troughs and deep scratches.

(ii) Intermediate Polishing:

It is carried out using emery paper of cogressively fine grades. The emery paper should be of good quality. The different grades of emery paper used are 120,240,320,400 and 1/0, 2/0, 3/0, 4/0 (Grain size from coarse to fine). The emery paper should be kept against the specimen and moved gently until a fine matrix of uniformly spaced scratches appears on the object. Final grade is then chosen and the specimen is turned perpendicular to the previous direction. This operation is usually done dry.

(iii) Fine Polishing:

An approximate flat scratch free surface is obtained by the use of wet rotary wheel covered with abrasive of alumina powder of 0.05 microns. In this operation, water is used as lubricant and carrier of the abrasive so that it comes in contact to specimen to be polished. Fine polishing removes fine scratches and very thin layer produced due to previous operations.

(iv) Etching:

The polished surface is washed with water and etching is done by rubbing the polished surface gently with cotton wetted with etching reagent. After etching the specimen is again washed and then dried. It is then placed under the metallurgical microscope to view the microstructure of it. Thus the specimen is identified.

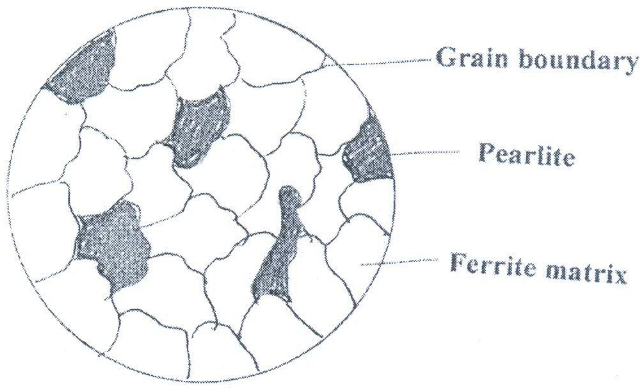
RESULT:

Thus the specimen was prepared for microscope observation for its identification.

INDENTOR USED: ....

Sl.No.	HARDNESS VALUE (SCALE :..........)	
	BEFORE NORMALISING	AFTER NORMALISING
1		
2		
3		

NORMALISED PLAIN CARBON STEEL



Magnification: x 675

Etchant: Nital solution

3. HEAT TREATMENT - NORMALISING

AIM:

To normalise the given plain carbon steel specimen.

TOOLS REQUIRED:

- Muffle furnace
- Hardness testing machine- Rockwell Hardness Machine
- Microscope

THEORY:

Normalising is one of the heat treatment processes in which the steel is heated above 800°C,holding the specimen at this temperature for a specified period of time followed by cooling it in still air to room temperature. The cooling rate is 30-50°C per minute. The resultant microstructure is Pearlite. Normalising refines the grains, improves sub-structure, hardness, strength, toughness and machinability with the release of residual stresses.

PROCEDURE:

1) Measure the hardness of given specimen in Rockwell hardness testing machine.
2) Put on the temperature controllable furnace.
3) When the temperature in furnace is 800°C keep the specimen inside it.
4) Allow the specimen to be in furnace for 15 – 20 minutes at 800°C temperature.
5) Put off the furnace and take the specimen out.
6) Cool the specimen for 30 - 60 minutes in air.
7) Measure the hardness again in Rockwell hardness testing machine.
8) Confirm the presence of Pearlite under microscopic view.

OBSERVATION:-

BEFORE NORMALISING:

AFTER NORMALISING:

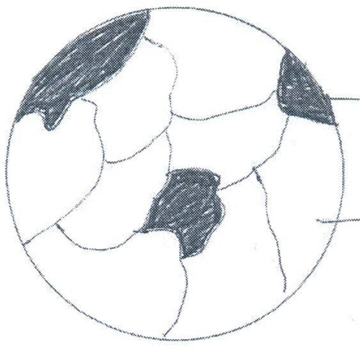
RESULT:

Thus the normalizing – heat treatment process is carried out.

INDENTOR USED: ....

Sl.No.	HARDNESS VALUE (SCALE :..........)	
	BEFORE ANNEALING	AFTER ANNEALING
1		
2		
3		

ANNEALED PLAIN CARBON STEEL



Etchant: Nital solution **Magnification: x 675**

4. HEAT TREATMENT - ANNEALING

AIM:

To anneal the given plain carbon steel specimen.

TOOLS REQUIRED:

- Muffle furnace
- Hardness testing machine- Rockwell Hardness Machine
- Microscope

THEORY:

Annealing is one of the heat treatment processes in which the steel is heated above 800°C, holding the specimen at this temperature for a specified period of time followed by cooling it inside the furnace. The cooling rate is 20-30°C per minute. The resultant microstructure is Ferrite. As this transformation takes place inside the furnace, the cooling rate is very slow and hence it improves softness and ductility, relieves internal stresses, refines the grains and redistributes the dispersed phases i.e. uniformity of phase distribution is increased. It also improves machinability, electrical and magnetic properties. The annealing temperature depends on the percentage of carbon in steel.

PROCEDURE:

1) Measure the hardness of given specimen in Rockwell hardness testing machine.
2) Put on the temperature controllable furnace.
3) When the temperature in furnace is 800°C keep the specimen inside it.
4) Allow the specimen to be in furnace for 15 – 20 minutes at 800°C temperature.
5) Put off the furnace and Cool the specimen inside the furnace for 1- 2 hours.
6) Measure the hardness again in Rockwell hardness testing machine.
7) Confirm the presence of Ferrite under microscopic view.

OBSERVATION:-

BEFORE ANNEALING:

AFTER ANNEALING:

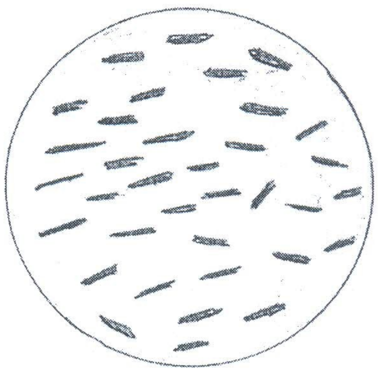
RESULT:

Thus the Annealing – heat treatment process is carried out.

INDENTOR USED: ....

Sl.No.	HARDNESS VALUE (SCALE :..........)	
	BEFORE HARDENING	AFTER HARDENING
1		
2		
3		

HARDENED PLAIN CARBON STEEL



Magnification: x 675

Etchant: Nital solution

5. HEAT TREATMENT - HARDENING

AIM:

To harden the given plain carbon steel specimen.

TOOLS REQUIRED:

- Muffle furnace
- Hardness testing machine- Rockwell Hardness Machine
- Microscope

THEORY:

Hardening is one of the heat treatment processes in which the steel is heated above 850°C, holding the specimen at this temperature for a specified period of time followed by cooling it by quenching the specimen in water. The cooling rate is 80-100°C per minute. The resultant microstructure is Martensite. The hardening is done to improve mechanical properties like strength, elasticity, ductility and toughness, to improve wear resistance and to develop high hardness.

PROCEDURE:

1) Measure the hardness of given specimen in Rockwell hardness testing machine.
2) Put on the temperature controllable furnace.
3) When the temperature in furnace is 850°C keep the specimen inside it.
4) Allow the specimen to be in furnace for 10– 15 minutes at 850°C temperature.
5) Put off the furnace.
6) Take the specimen and quench it by dipping in water.
7) Measure the hardness again in Rockwell hardness testing machine.
8) Confirm the presence of Martensite under microscopic view.

OBSERVATION:-

BEFORE HARDENING:

AFTER HARDENING:

RESULT:

Thus the Hardening – heat treatment process is carried out.

INDENTOR USED:..

Sl.No.	HARDNESS VALUE (SCALE:...................)	
	BEFORE TEMPERING	AFTER TEMPERING
1		
2		
3		

TEMPERED MARTENSITE

MAGNIFICATION : 100X **ETCHANT: NITAL SOLUTION**

6. HEAT TREATMENT - TEMPERING

AIM:

To study the effects of Heat Treatment-Tempering process in the given hardened steel specimen.

TOOLS REQUIRED:

- Muffle furnace
- Hardness testing machine- Rockwell Hardness Machine
- Microscope

THEORY:

Steels that have undergone hardening by quenching are usually mixture of austenite and martensite, with later constituent predominating. Both of these structures are unstable and slowly decompose in to stable phases. Tempering of steel is a process in which previously hardened or normalized steel is usually heated to a temperature below the lower critical temperature (723°C) and cooled to room temperature at slow cooling rate. Tempering is done, primarily to increase ductility and toughness, to increase the grain size of the matrix, to relieve quenching stresses and to ensure dimensional stability. Tempering process would end in the conversion of martensite structure to cementite in the ferrite matrix.

PROCEDURE:

1. Measure the hardness of given specimen in Rockwell hardness testing machine.
2. Put on the temperature controllable furnace.
3. When the temperature in furnace is 550°C keep the specimen inside it.
4. Allow the specimen to be in furnace for 30 minutes at 550°C temperature.
5. Put off the furnace.
6. Take the specimen and quench it by dipping in water.
7. Measure the hardness again in Rockwell hardness testing machine.
8. Confirm the presence of cementite in the ferrite matrix under microscopic view.

OBSERVATION:-

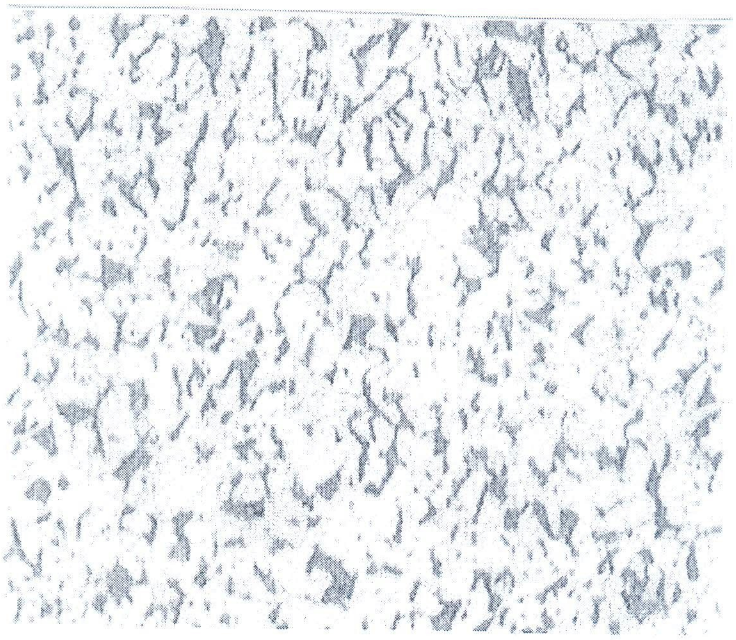
BEFORE TEMPERING:

AFTER TEMPERING:

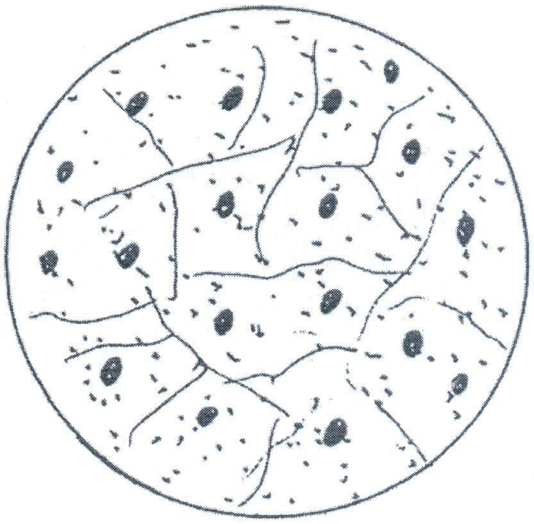
RESULT:

Thus the effect of Heat Treatment-Tempering process in the given hardened steel specimen was studied.

LOW CARBON STEEL



Magnification: 100x ETCHANT: Nital Solution



7. IDENTIFICATION OF LOW CARBON STEEL

AIM:

To identify the given specimen and to study the microstructure, characteristics and applications of it.

TOOLS REQUIRED:

- Linisher – polisher,
- Emery sheets,
- Disc polisher,
- Alumina powder,
- Etchant and
- Metallurgical microscope.

PROCEDURE:

1) The specimen is abraded against the linisher polisher to remove burs.
2) Then it is polished using the various grades of emery paper.
3) The specimen is fine polished in disc polishing machine using alumina powder as lubricant.
4) Then the specimen is washed thoroughly in water and then etched with nital solution.
5) After etching the specimen is washed and dried for some seconds.
6) Now view the structure under microscope.

IDENTIFICATION:

The structure is pearlite and the specimen is identified as **Low Carbon Steel**. The pearlite is a lamellar structure of cementite in ferrite matrix.

CHARACTERISTICS OF LOW CARBON STEEL:

- High ductility and toughness
- Possesses good formability and weldability
- Least expensive
- Low tensile strength

APPLICATIONS OF LOW CARBON STEEL:

- It is used for manufacturing products like screws, nails, nut, bolt, washers, wire fences etc.
- Automobile body components
- Structural steels, bars, grills, angles etc.

OBSERVATION:

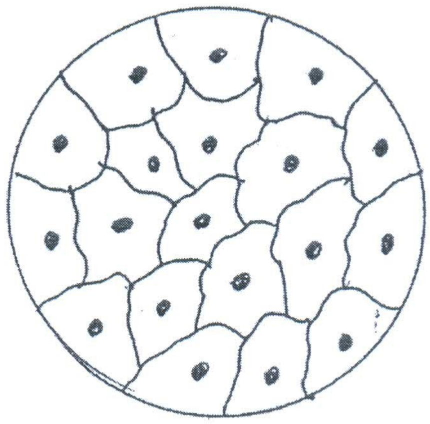
RESULT:

Thus the given specimen is identified as **Low Carbon Steel** and its characteristics and applications were studied.

AUSTENITIC STAINLESS STEEL

Magnification: 100x

Etchant: Aqua Solution



8. IDENTIFICATION OF AUSTENITIC STAINLESS STEEL

AIM:

To identify the given specimen and to study the microstructure, characteristics and applications of it.

TOOLS REQUIRED:

- Linisher – polisher,
- Emery sheets,
- Disc polisher,
- Alumina powder,
- Etchant and
- Metallurgical microscope.

PROCEDURE:

1) The specimen is abraded against the linisher polisher to remove burs.
2) Then it is polished using the various grades of emery paper.
3) The specimen is fine polished in disc polishing machine using alumina powder as lubricant.
4) Then the specimen is washed thoroughly in water and then etched with aqua regia.
5) After etching the specimen is washed and dried for some seconds.
6) Now view the structure under microscope.

IDENTIFICATION:

The structure is austenite and the specimen is identified as **Austenitic Stainless Steel.**

CHARACTERISTICS OF AUSTENITIC STAINLESS STEEL:

- Highest corrosion resistance
- Good ductility at cryogenic temperature i.e. below $0^{\circ}C$
- Non- magnetic

APPLICATIONS OF AUSTENITIC STAINLESS STEEL:

- Engine parts

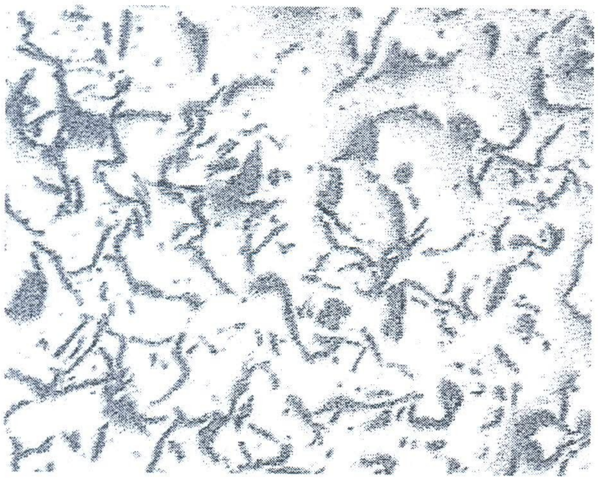
- Heat exchangers
- Food processing and house hold items
- Dairy industry

OBSERVATION:

RESULT:

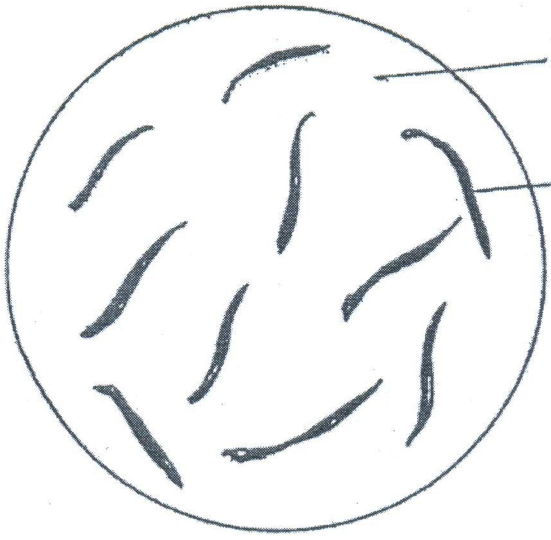
Thus the given specimen is identified as **Austenitic Stainless Steel** and its characteristics and applications were studied.

GREY CAST IRON



As Polished - Magnification : 100x

As Etched - Magnification:250x
Etchant : Nital Solution



9. IDENTIFICATION OF GREY CAST IRON

AIM:

To identify the given specimen and to study the microstructure, characteristics and applications of it.

TOOLS REQUIRED:

- Linisher – polisher,
- Emery sheets,
- Disc polisher with Alumina powder,
- Etchant and
- Metallurgical microscope.

PROCEDURE:

1) The specimen is abraded against the linisher polisher to remove burs.
2) Then it is polished using the various grades of emery paper.
3) The specimen is fine polished in disc polishing machine using alumina powder as lubricant.
4) Then the specimen is washed thoroughly in water and then etched with nital solution.
5) After etching the specimen is washed and dried for some seconds.
6) Now view the structure under microscope.

IDENTIFICATION:

The structure is graphite flakes in ferrite matrix and the specimen is identified as **Grey Cast Iron**.

CHARACTERISTICS OF GREY CAST IRON:

- Excellent compressive strength
- Good torsional and shear strength
- Good corrosion resistance
- High damping capacity

APPLICATIONS OF GREY CAST IRON:

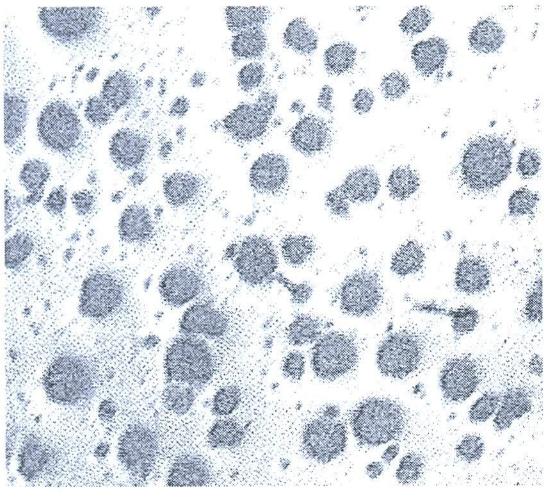
- Machine tool bodies
- Engine blocks
- Cam shafts
- Rolling mills, agricultural machineries etc.

OBSERVATION:

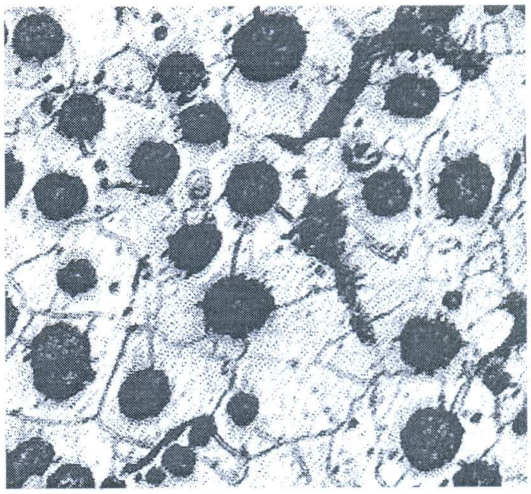
RESULT:

Thus the given specimen is identified as **Grey Cast Iron** and its characteristics and applications were studied.

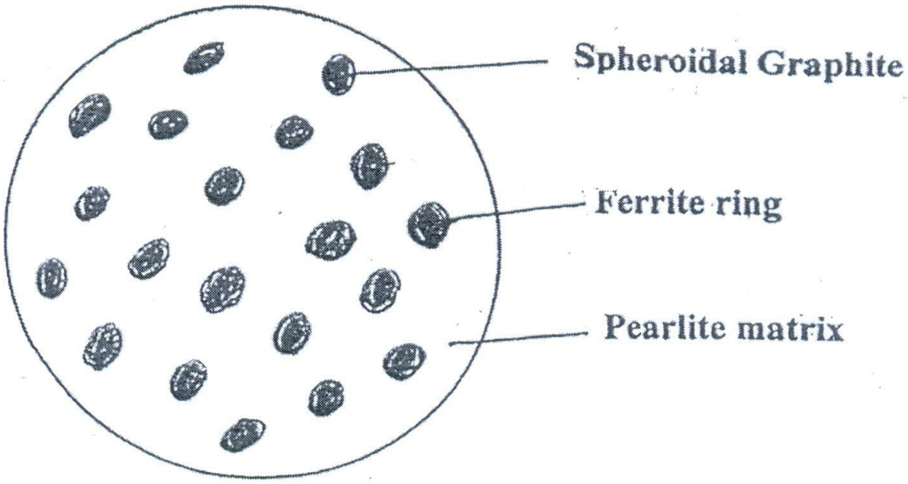
NODULAR CAST IRON / SPHEROIDAL GRAPHITE CAST IRON



As Polished-Magnification:100x



As Etched - Magnification:250x
Etchant : Nital Solution



10. IDENTIFICATION OF NODULAR CAST IRON

AIM:

To identify the given specimen and to study the microstructure, characteristics and applications of it.

TOOLS REQUIRED:

- Linisher – polisher,
- Emery sheets,
- Disc polisher with Alumina powder,
- Etchant and
- Metallurgical microscope.

PROCEDURE:

1) The specimen is abraded against the linisher polisher to remove burs.
2) Then it is polished using the various grades of emery paper.
3) The specimen is fine polished in disc polishing machine using alumina powder as lubricant.
4) Then the specimen is washed thoroughly in water and then etched with nital solution.
5) After etching the specimen is washed and dried for some seconds.
6) Now view the structure under microscope.

IDENTIFICATION:

The structure is graphite nodules in a matrix of ferrite and pearlite with a majority of ferrite content and the specimen is identified as **Nodular Cast Iron**.

CHARACTERISTICS OF NODULAR CAST IRON:

- ❖ Good ductility and malleability
- ❖ High yield strength and tensile strength
- ❖ Excellent impact and fatigue strength
- ❖ Excellent machinability
- ❖ Ability to resist oxidation at high temperatures

APPLICATIONS OF NODULAR CAST IRON:

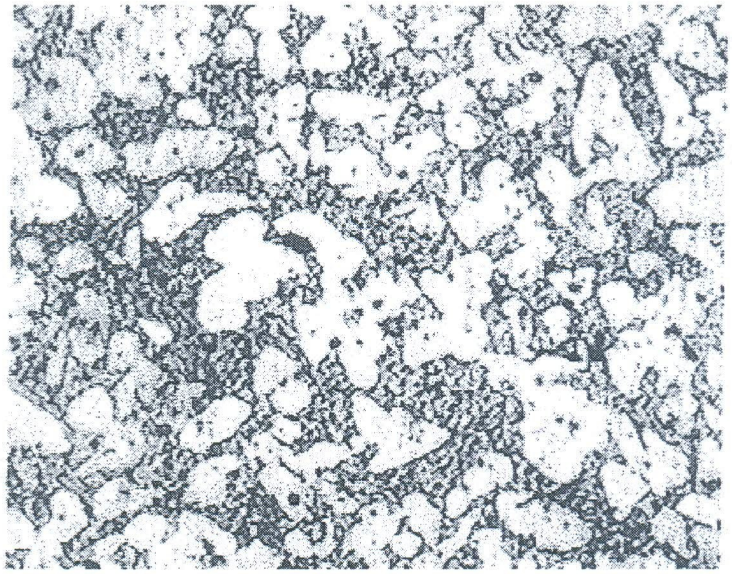
- Valves, pumps
- Gears, pinions
- Crank shafts,
- Power transmission equipments

OBSERVATION:

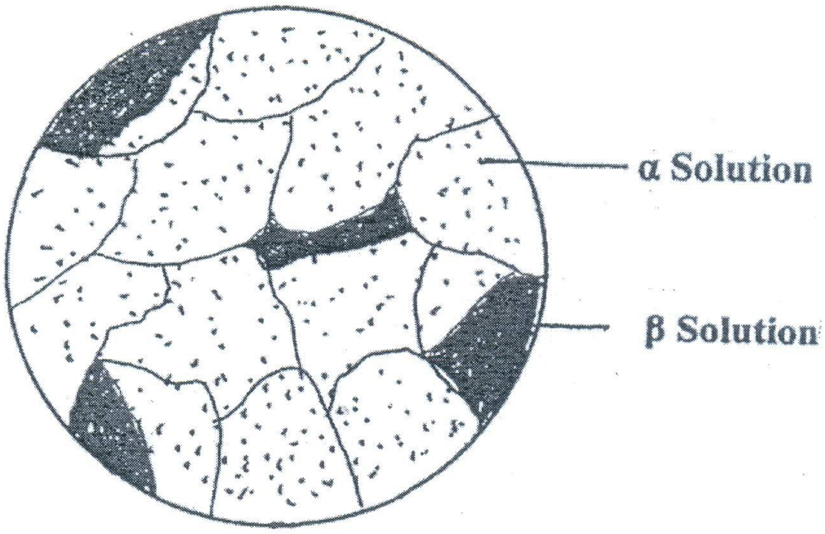
RESULT:

Thus the given specimen is identified as **Nodular Cast Iron** and its characteristics and applications were studied.

BRASS (COPPER ALLOY)



Magnification : 200x Etchant: Ammonia & H_2O_2 Solution



11. IDENTIFICATION OF BRASS (COPPER ALLOY)

AIM:

To identify the given specimen and to study the microstructure, characteristics and applications of it.

TOOLS REQUIRED:

- Linisher – polisher,
- Emery sheets,
- Disc polisher with Alumina powder,
- Etchant and
- Metallurgical microscope.

PROCEDURE:

1) The specimen is abraded against the linisher polisher to remove burs.
2) Then it is polished using the various grades of emery paper.
3) The specimen is fine polished in disc polisher using alumina powder as lubricant.
4) Then the specimen is washed thoroughly in water and then etched with ammonia and hydrogen oxide solution.
5) After etching the specimen is washed and dried for some seconds.
6) Now view the structure under microscope.

IDENTIFICATION:

The structure is equiaxed grains of alpha in a matrix of beta solid solution and the specimen is identified as **Brass (Copper alloy)**. The black spots are due to shrinkage cavity formed during casting.

CHARACTERISTICS OF BRASS:

- Cast into moulds, into wires into sheets etc.
- Colour of brass changes from red to white, depending on the amount of zinc present.

APPLICATIONS OF BRASS:

- Jewelleries

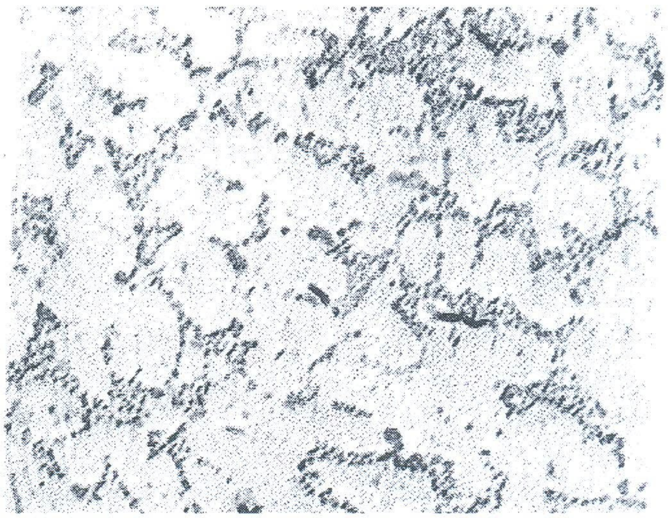
- Pumps, tubes
- Springs
- Screws

OBSERVATION:

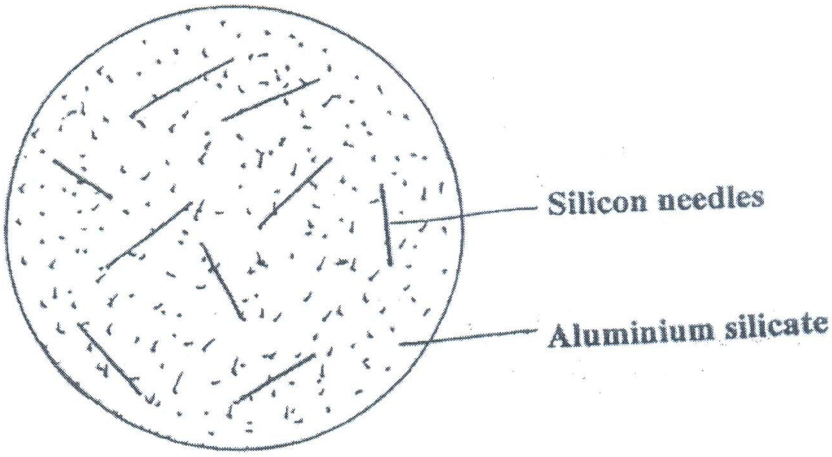
RESULT:

Thus the given specimen is identified as **Brass (Copper alloy)** and its characteristics and applications were studied.

ALUMINIUM ALLOY



Magnification : 100x Etchant: Hydrofluoric Acid



12. IDENTIFICATION OF ALUMINIUM ALLOY

AIM:

To identify the given specimen and to study the microstructure, characteristics and applications of it.

TOOLS REQUIRED:

- Linisher – polisher,
- Emery sheets,
- Disc polisher,
- Alumina powder,
- Etchant and
- Metallurgical microscope.

PROCEDURE:

1) The specimen is abraded against the linisher polisher to remove burs.
2) Then it is polished using the various grades of emery paper.
3) The specimen is fine polished in disc polishing machine using alumina powder as lubricant.
4) Then specimen is washed thoroughly in water and etched with hydrofluoric acid.
5) After etching the specimen is washed and dried for some seconds.
6) Now view the structure under microscope.

IDENTIFICATION:

The structure shows very fine grains of aluminium-silicon in a matrix of aluminium solid solution and the specimen is identified as **Aluminium alloy**.

CHARACTERISTICS OF ALUMINIUM ALLOY:

- Light weight
- High strength to weight ratio
- High reflectivity
- Non toxicity

APPLICATIONS OF ALUMINIUM ALLOY:

- Aeroplane parts
- Precision instruments
- Furnitures, electrical conductors
- Corrugated sheets, windows etc.

OBSERVATION:

RESULT:

Thus the given specimen is identified as **Aluminium alloy** and its characteristics and applications were studied.

METALLURGY LAB
VIVA VOCE QUESTIONS

1. The ability of a material to resist softening at high temperature is known as
   a) Creep b) hot tempering
   c) Hot hardness d) fatigue
   e) Super hardening

2. Mild steel belong to the following category
   a. Low carbon steel
   b. Medium carbon steel
   c. High carbon steel
   d. Alloy steel
   e. Special steel

3. The ultimate tensile strength of low carbon steel by working at a high strain rate will
   a. Decrease
   b. Increase
   c. Remain constant
   d. First increase and then decrease
   e. First decrease and then increase

4. Recrystallation temperature is one
   a) at which crystals first start forming from molten metals when it is cooled
   b) at which new spherical crystals first begin to form from the old deformed one when a strained metal is heated
   c) At which change of allotropic form takes place
   d) at which crystals grow bigger in size
   e) at which crystals destroyed on heating

5. Points of arrest for iron correspond to
   a) stages at which allotropic form change
   b) Stages at which further heating does not increase temperature for sometime
   c) stages at which properties do not change with increase in temperature
   d) there is nothing like point of arrest
   e) none of the above

6. Delta iron occurs at temperature of
   a) room temperature
   b) above melting point
   c) between 1400° C and 1539° C
   d) between 910° C and 1400°C
   e) none of the above

7. A material is known as allotropic or polymorphic if it
   a) has a fixed structure under all conditions
   b) Exists in several crystal forms at different temperatures
   c) Responds to heat treatment
   d) has its atoms distributed in a random pattern
   e) None of the above

8. Which of the following constituents of steel is softest and least strong?
   a) Austenite
   b) pearlite
   c) Ferrite
   d) cementite
   e) Bauxite

9. Which of the following represents allotropic forms of iron?
   a) Alpha iron, beta iron and gamma iron
   b) Alpha iron and beta iron
   c) Body centered cubic œ-iron and face centered cubic œ-iron
   d) Alpha iron, gamma iron and delta iron
   e) None of the above

10. Pure iron is the structure of
   a) Ferrite
   b) pearlite
   c) Austenite
   d) ferrite and cementite
   e) Ferrite and pearlite

11. The temperature at which ferromagnetic alpha iron transforms into paramagnetic alpha iron is
   a) 770° c
   b) 910° c
   c) 1050° c
   d) below recrystallaisation temperature
   e) Above recrystallaisation temperature

12. Gamma iron exists at following temperature
   a) room temperature
   b) near melting point
   c) between 1400°c and 1539°c
   d) between 910°c and 1400°c
   e) None of the above

13. Ferromagnetic alpha iron exists in the temperature range of
   a) below 723°c
   b) 770 – 910°c
   c) 910 – 1440°c
   d) 1400 – 1539°c
   e) above 1539°c

14. Paramagnetic alpha iron changes to gamma iron at

a) 770° c b) 910 °c

c) 1440° c d) 1539° c e) None of the above

15. The crystal structure of gamma iron is

a) Body centered cubic
b) Face centered cubic
c) Hexagonal close packed
d) cubic structure
e) Orthorhombic crystal

16. The crystal of alpha iron is

a) body centered cubic
b) face centered cubic
c) hexagonal close packed
d) cubic structure
e) Orthorhombic crystal

17. The metallic structure of mild steel is

a) Body centered cubic
b) Face centered cubic
c) Hexagonal close packed
d) Cubic structure
e) Orthorhombic crystal

18. For the allotropic forms of iron, the points of arrest are

a) the points where no further change occurs
b) constant for all metals
c) the points where there is no further flow of metals
d) the points of discontinuity
e) the points where major change place

19. The percentage of carbon in pig iron varies from

a) 0.1 to 1.2% b) 1.5 to 2.5%

c) 2.5 to 4 % d) 4 to 4.5% e) 4.5 to 6.3%

20. The percentage of carbon in grey iron castings usually varies between

a) 0.5 to 1% b) 1 – 2%

c) 2.5 to 4.5% d) 5-7% e) 7-9%

21. Pig iron is the name given to

a) raw material for blast furnace
b) product of blast furnace made reduction of iron ore
c) iron containing huge quantities carbon
d) iron in molten form in the ladles
e) iron scrap

22. The unique property of cast iron is its high

a) Malleability
b) Ductility
c) Surface finish
d) Damping characteristics
e) Hardness

23. Cast iron is characterized by minimum following percentage of carbon

a) 0.2% b) 0.8%
c) 1.3% d) 2%
e) 6.3%

24. In grey cast iron, carbon is present in form of

a) Cementite b) free carbon
c) flakes c) spheroids
e) Nodular aggregates of graphite

25. In nodular iron, graphite is in the form

a) Cementite b) free carbon
c) Flakes c) spheroids
e) Nodular aggregates of graphite

26. In malleable iron, carbon is present in the form of

a) Cementite b) free carbon
c) Flakes c) spheroids
e) Nodular aggregates of graphite

27. Wrought iron is

a) hard
b) high in strength
c) highly resistant to corrosion
d) heat treated to change its properties
e) least resistant to corrosion

28. Sulphur in pig iron tends to make it

a) Hard b) soft
c) Ductile d) tough e) Malleable

29. Pick up wrong statement about wrought iron

a) it contains carbon of the order of 0 to 0.25%
b) it melts at 1535°c
c) it is very soft and ductile
d) it can be easily forge welded
e) it is made by adding suitable percentage of carbon to molten iron and subjecting the product to repeat hammering and rolling

30. Iron is

a) Paramagnetic
b) Ferromagnetic
c) Ferroelectric
d) Dielectric
e) None of the above

31. A reversible change in the atomic structure of the steel with a corresponding change in the properties is known as

a) allotropic change
b) recrystallisation
c) heat treatment
d) precipitation
e) Austempering

32. Chilled cast iron has

a) no graphite
b) a very high percentage of graphite
c) a low percentage of graphite
d) graphite as its basic constituent of composition
e) None of the above is true

33. Cast iron has

a) high tensile strength
b) its elastic limit close to ultimate breaking strength
c) high ductility
d) all of the above
e) none of the above

34. White cast iron contains carbon in the form of

a) Free carbon b) graphite
c) Cementite d) white carbon e) Ferrite

35. In mottled cast iron, carbon is available in

a) Free form b) combined form
c) Nodular form d) flat form
e) Partly in free and partly in combined state

36. An important property of silicon (12-18%) cast iron is the high

a) tenacity b) brittleness
c) plasticity d) corrosion resistance e) Hardness

37. An important property of malleable cast iron in comparison to grey cast iron is the high

a) Compressive strength
b) Ductility
c) Carbon content
d) Hardness
e) Surface finish

38. First material known to be used by man
(a) Cotton (b) Bronze (c) Iron (d) Rock

39. First metal known to be used by man
(a) Iron (b) Bronze (c) Silver (d) Aluminium

40. Which one of the following is not basic component of Materials Science?
(a) Cost (b) Properties (c) Structure (d) Performance

41. Figure out the odd statement about ceramics in the following
(a) Good insulators of heat and electricity (b) Usually less desire than metals
(c) Ductile in nature (d) Contains both metallic and nonmetallic elements

42. Pick the composite from the list
(a) Wood (b) Steel (c) Nylon (d) Mica

43. Not an example for actuator
(a) Optical fiber (b) Shape memory alloys
(c) Magneto-strictive materials (d) Electro-/Magneto-rheological fluids

44.Strong and ductile materials
(a) Polymers (b) Ceramics (c) Metals (d) Semiconductors

45. Presently most used metal in the world
(a) Aluminium (b) Gold (c) Steel (d) Silver

46. Detrimental property of a material for shock load applications
(a) High density (b) Low toughness (c) High strength (d) Low hardness

47. Democratic material
(a) Diamond (b) Titanium (c) Iron (d) Gold

48. 3% C in medium carbon steels ranges from _____________.
(a) 0.3 – 0.4 (b) 0.3 – 0.5 (c) 0.3 – 0.6 (d) None

49. Stainless steel is so called because of its ________________.
(a) High strength (b) High corrosion resistance (c) High ductility (d) Brittleness

50. In white cast irons, carbon present as ________________.
(a) Graphite flakes(b) Graphite nodules (c) Cementite (d) Carbon does not exist

51. Refractory metal
(a) Ag (b) W (c) Pt (d) Ni

52. Not a noble metal
(a) Cu (b) Ag (c) Au (d) Pt

53. Noble metal
(a) Al (b) Ag (c) Mo (d) W

54. Usual casting method for making dental crowns
(a) Sand casting (b) Die casting(c) Continuous casting (d) Investment casting

55. Prime structural disadvantage of P/M products
(a) Low density (b) Porosity (c) High damping capacity (d) None

56. Not an important heat treatment process parameter
(a) Heating rate (b) Temperature (c) Cooling rate (d) Atmosphere

57. Final structure of austempered steel
(a) Pearlite(b) Ferrite + graphite (c) Bainite (d) Martensite

58. The hot working and cold working of metals are carried out by
a) both are above the recrystalization temperature
b) both are above the recrystalization temperature
c) above the recrystalization and below the recrystalization temperature respectively
d) below the recrystalization and above the recrystalization temperature respectively

59. Kevlar is commercial name for ___________ .
(a) Glass fibers (b) Carbon fibers (c) Aramid fibers (d) Cermets

60. Example for ferro-magnetic materials
(a) super conductors (b) alkali metals (c) transition metals (d) Ferrites

Answers:

1. c	2. a
3. b	4. b
5. a	6. c
7. b	8. c
9. d	10. a
11. a	12. d
13. a	14. b
15. b	16. a
17. a	18. d
19. d	20. c
21. b	22. d
23. d	24. c
25. d	26. e
27. c	28. a
29. e	30. b
31. a	32. a
33. b	34. c
35. e	36. e
37. b	38. d
39. b	40. a
41. c	42. a
43. a	44. c
45. c	46. b
47. c	48. c
49. b	50. c
51. b	52. a
53. b	54. d
55. b	56. a
57. c	58. c
59. c	60. c

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On looking a half filled glass,

Optimist	:	The glass is half full.
Pessimist	:	The glass is half empty.
Re-engg. Consultant	:	The glass is twice as large as it needs to be.

-The Economic Press, U.S.