USN :

CMR Institute of Technology, Bangalore
DEPARTMENT OF MECHANICAL ENGINEERING
III - INTERNAL ASSESSMENT

Semester: 4-CBCS 2018
Subject: METAL CASTING AND WELDING (18ME45B)
Faculty: Ms Shreyas P

Date: 30 Jul 2021
Time: 01:00 PM - 02:30 PM
Max Marks: 50

Instructions to Students :

Answer all FOUR questions.

Answer All Questions

Q.No		Marks	CO	PO	BT/CL
1	With neat sketches explain the working principles of TIG and MIG welding.	20	CO6	PO1,PO2,PO10	L2
2	With neat sketches explain the working principles of Thermit Welding.	10	CO6	PO1,PO2,PO10	L2
3	List any 6 weld defects and also explain their causes and remedies.	10	CO7	PO1,PO2,PO10	L2
4	Define Non Destructive Testing and also explain how a defect is detected using the ultrasound Inspection Method.	10	CO7	PO1,PO2,PO10	L2

Metal Casting and Welding

IAT 3 Scheme (Even Sem 2020-21)

Question Number	Particulars	Marks Alloted
1	Sketch of TIG welding	6
	Sketch of TIG welding	6
	Construction and working of TIG welding	4
	Construction and working of TIG welding	4
2	Sketch of Thermit welding	6
	Construction and working of Thermit welding	4
3	Listing any 6 welding defects	3
	Explaining their causes and remedies	7
4	Definition of Non Destructive testing	2
	Sketch of Ultra sound Inspection	5
	Construction and working of Ultra sound Inspection	3

Metal Casting and Welding

IAT 3 Solution (Even Sem 2020-21)

1.

4.9 TUNGSTEN INERT GAS WELDING (TIG)

Tungsten inert gas welding or *gas tungsten arc welding* (GTAW) is a group of welding process in which the workpieces are joined by the heat obtained from an electric arc, struck between a non-consumable tungsten electrode and the workpiece, in the presence of an inert gas* atmosphere. A filler metal may be added if required, during the welding process. Figure 4.3 shows the TIG process.

Description and Operation

a) TIG equipment consists of a welding torch in which a non-consumable *tungsten alloy electrode* is held rigidly in the collet. Various alloys like zirconium, thorium, lanthanum etc., are alloyed with *tungsten* to improve arc stability, better current carrying capacity, resistance to contamination etc. The diameter of the electrode varies from 0.5 – 6.4 mm.

b) TIG welding makes use of a inert gas (shielding gas) like *argon* or *helium* to protect the welding area from atmospheric gases such as oxygen and nitrogen, otherwise which may cause fusion defects and porosity in the weld metal.

The shielding gas flow from the cylinder, through the passage in the electrode holder, and then impinges on the workpiece. Pressure regulator and flow meters are used to regulate the pressure and flow of gas from the cylinder.

c) Either AC or DC can be used to supply the required current. AC is preferred for welding magnesium, aluminum and their alloys, while DC is used for welding stainless steel, nickel, copper and its alloys.

d) In operation, the workpieces to be joined are cleaned to remove dirt, grease and other oxides chemically or mechanically to obtain a sound weld.

---

e) The welding current and inert gas supply are turned ON. An arc is struck by touching the tip of the tungsten electrode with the workpiece, and instantaneously the electrode is separated from the workpiece by a small distance of 1.5 – 3 *mm* such that the arc still remains between the electrode and the workpiece.

f) The high intensity of the arc melts the workpiece metal forming a small molten metal pool. Filler metal in the form of a rod is added manually to the front end of the weld pool.

g) The deposited filler metal fills and bonds the joint to form a single piece of metal.

---

h) The arc is extinguished by widening the gap between the workpiece and the electrode. The shielding gas is allowed to impinge on the solidifying weld pool for a few seconds even after the arc is extinguished. This will avoid atmospheric contamination of the solidifying metal thereby increasing the strength of the joint.

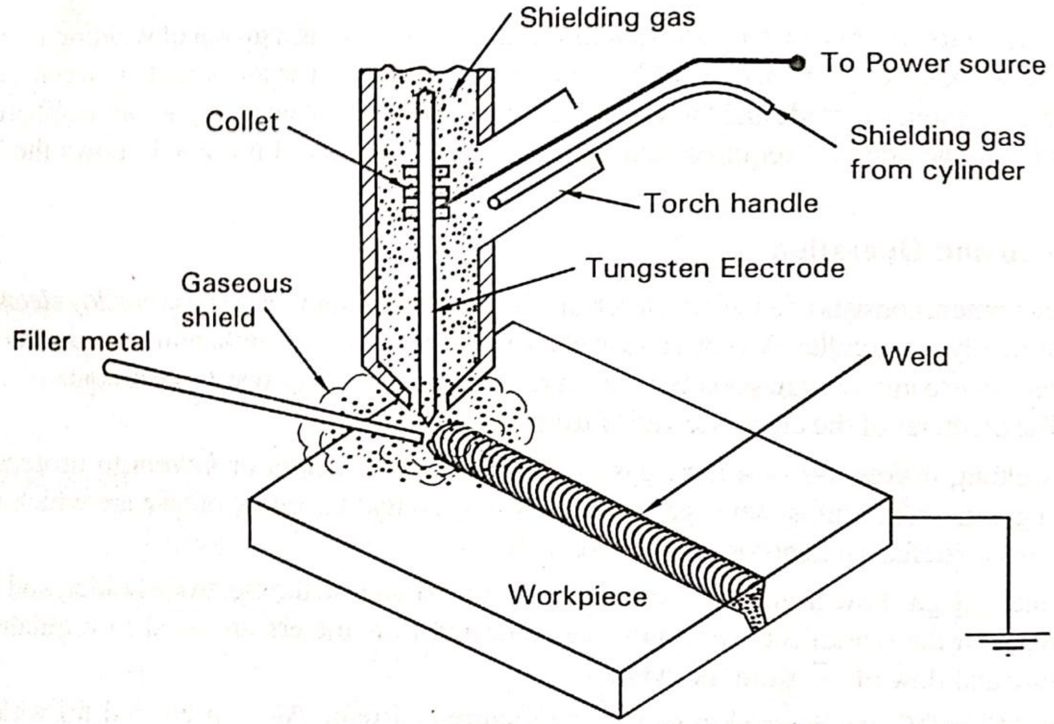


Figure 4.3 Tungsten Inert Gas (TIG) welding

4.10 METAL INERT GAS (MIG) WELDING

Metal inert gas welding or *gas metal arc welding* (GMAW) is a group of arc welding process in which the workpieces are joined by the heat obtained from an electric arc struck between a bare (uncoated) consumable electrode and the workpiece in the presence of an inert gas atmosphere. The consumable electrode acts as a filler metal to fill the gap between the two workpieces. Figure 4.4 shows the MIG welding process.

Description and Operation

a) The equipment consists of a welding torch in which a bare (uncoated) consumable electrode in the form of a *wire* is held and guided by a guide tube. The electrode material used in MIG welding is of the same material or nearly the same chemical composition as that of the base metal. Its diameter varies from 0.7 – 2.4 *mm*. The electrode is fed continuously at a constant rate through feed rollers driven by an electric motor.

b) MIG makes use of shielding gas to prevent atmospheric contamination of the molten weld pool. Mixture of argon and carbon dioxide in a 75% to 25% or 80% to 20% mixture is commonly used. The shielding gas flow from the cylinder, through the passage in the electrode holder, and then impinges on the workpiece.

c) AC is *rarely* used with MIG welding; instead DC is employed, and the electrode is positively charged. This results in faster melting of the electrode, which increases weld penetration and welding speed.

d) In operation, the workpieces to be joined are cleaned to remove dust, grease and other oxides, chemically or mechanically to obtain a sound weld. The tip of the electrode is also cleaned with a wire brush.

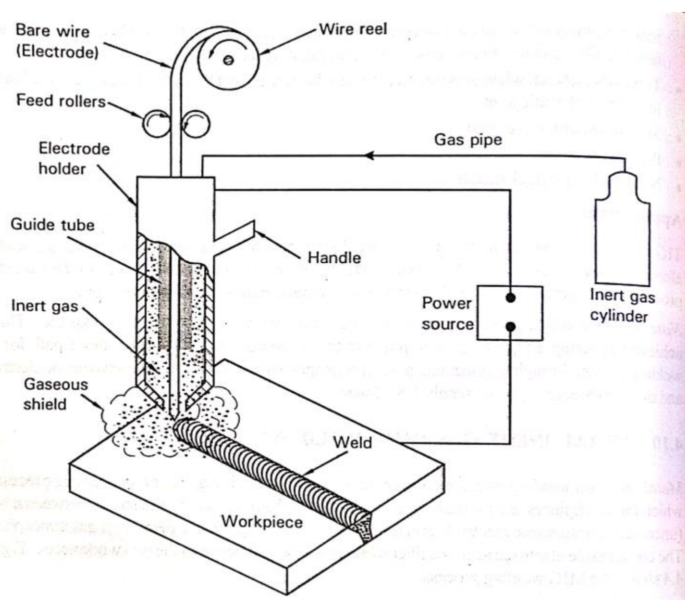


Figure 4.4 Metal Inert Gas (MIG) welding

Figure 4.4 Metal Inert Gas (MIG) welding

e) The control switch provided in the welding torch is switched ON to initiate the electric power, shielding gas and the wire (electrode) feed.

f) An arc is struck by touching the tip of the electrode with the workpiece, and instantaneously the electrode is separated from the workpiece by a small distance of 1.5 – 3 *mm* such that the arc still remains between the electrode and the workpiece.

g) The high intensity of the arc melts the workpiece metal forming a small molten pool. At the same time, the tip of the electrode also melts and combines with the molten metal of the workpieces thereby filling the gap between the two workpieces.

h) The deposited metal upon solidification bonds the joint to form a single piece of metal.

Advantages

2.

... with this process.

4.16 THERMIT WELDING

Thermit welding or *alumino-thermit welding* is a fusion welding process in which the workpieces are joined by the heat obtained from a chemical reaction of the thermit mixture. Pressure may or may not be applied during the process.

The thermit mixture is a mixture of iron oxide and aluminum powder, and when this mixture is brought to its ignition temperature of about 1200°C, reaction starts, producing molten iron and slag (Al_2O_3) releasing enormous amount of heat. The reaction taking place is as per the following:

$$3\,Fe_3O_4 + 8\,Al \rightarrow 9\,Fe + 4\,Al_2O_3 + \text{heat}$$

The molten iron (*Fe*) thus obtained is poured into the cavity (gap between the two workpieces) and upon solidification, complete fusion takes place. Figure 4.13 shows the welding of rail joint (I-section) using thermit welding process.

Description and Operation

a) The edges of the workpiece are cut flat and cleaned to remove dirt, grease and other impurities to obtain a sound weld. A gap of about 1.5 – 6 *mm* is left between the edges of the two workpieces as shown in figure.

b) A wax heated to its plastic state is poured in the gap between the workpieces to be joined and allowed to solidify. Excess wax solidified around the joint is removed.

c) A mould box is placed around the joint and packed with sand providing necessary gates and risers. A hole or heating gate is made in the mould connecting to the joint as shown in figure.

d) The wax material is melted out by means of a flame directed into the heating gate and ...

... the mould connecting to the joint as shown in figure.

d) The wax material is melted out by means of a flame directed into the heating gate, so that it leaves a cavity at the joint which will later be occupied by the molten metal. The heating gate is then closed with a sand core or iron plug.

e) A crucible containing the thermit mixture is suspended above the pouring cup. The mixture is ignited by lighting a magnesium ribbon or sparkler.

f) Exothermic reaction occurs to form molten iron and slag which floats at the top. The temperature resulting from this reaction is approximately 2500°C. The reaction is allowed a specific time (around 60 seconds), and the slag is removed from the surface of the molten metal.

g) The plug at the bottom of the crucible is opened, and the molten metal is poured into the cavity. The molten metal acts as a filler metal, melts the edges of the joint and fuses to form a weld.

h) After the weld joint cools and solidifies, the mould is broken, risers are cut and the joint is finished by machining or grinding.

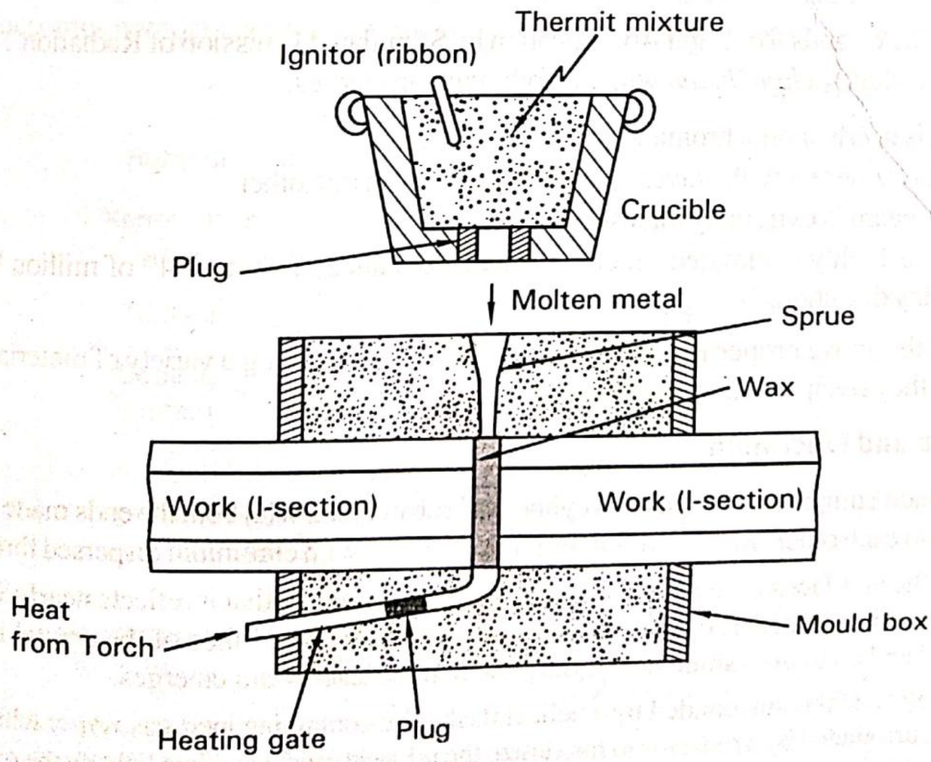


Figure 4.13 Thermit welding

3.

5.8 WELDING DEFECTS

Like casting, welding also involves various parameters viz., type of workpiece material, electrode material, power source, heat input, cooling rate, welding speed etc. Loss of control in any of these parameters may cause defects in the weld metal. Most of the defects encountered in welding are due to improper welding procedure. Some of the common defects and their causes are discussed below.

(a) Crack

Crack is a small, sharp split that occurs in the base metal, weld metal or at the interface between the two and are visible to the naked eye. Crack is a serious defect because they are seen as *stress raisers* capable to grow until fracture takes place. Refer figure 5.5(a).

Causes

- Incorrect technique for ending the weld.

- Poor ductility of the base metal.
- Combination of joint design and welding techniques, which results in a weld bead with an excessively concave surface that promote cracking.
- Low welding currents.
- Restrained joints – Joint members are not free to expand and contract when subjected to heat.

(b) Distortion

Distortion is the change in the original shape of the two workpieces after welding. Refer figure 5.5(b).

Causes

- High residual stresses due to shrinkage.
- High heat input.
- More number of passes.
- Slow welding speeds.

(c) Incomplete penetration

When the molten metal fails to penetrate the entire thickness of the base plate, it forms a bridge across the two plates causing a defect in the weld. Refer figure 5.5(c).

Causes

- Improper joint design.
- Low welding current.
- Slow arc travel speed.
- Incorrect torch angle.

(d) Inclusions

Inclusions are usually non-metallic particles such as slag or any foreign material that does not get a chance to float on the surface of the solidifying metal and thus gets trapped inside the same. Refer figure 5.5(d).

Causes

- Use of large electrodes in a narrow groove.
- Low currents that are insufficient for melting metal.
- High viscosity of the weld metal.

(e) Porosity

Porosities are small voids or cavities formed when gases are trapped in the solidifying weld metal. Porosity can occur either under or on the weld surface. Refer figure 5.5(e).

Source: ...

Causes

- Atmospheric contamination caused due to inadequate shielding gas.
- Excessively oxidized workpiece surfaces.
- Use of wet electrodes.
- Excessive gases released during welding.

(f) Under cut

Under cut, the worst of all defects is the term given to a sharp narrow groove along the toe of the weld due to the scouring action of the arc removing the metal and not replacing it with the weld metal. Refer figure 5.5(f).

Causes

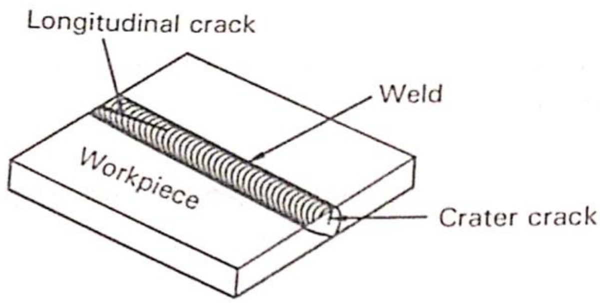
- High voltage and welding currents.
- High arc travel speed.
- Incorrect electrode manipulation.
- Arc gap too long.

(g) Lack of fusion or overlapping

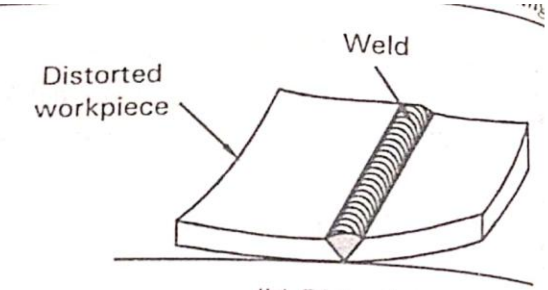
Lack of fusion is the failure of a welding process to fuse together layers of the base metal. The weld metal just rolls over the workpiece surfaces. Refer figure 5.5(g).

Causes

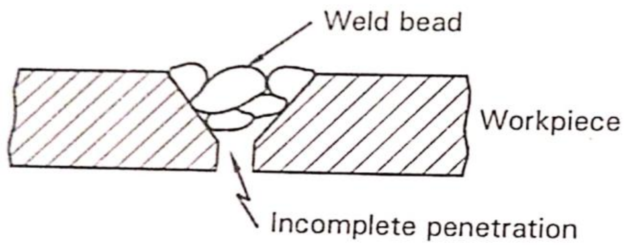
- Low welding currents that are insufficient to raise the temperature of the workpiece metal to melting point.
- Excessive surface impurities of workpiece.
- Improper electrode type/size.
- Wrong polarity.
- Low arc travel speed.



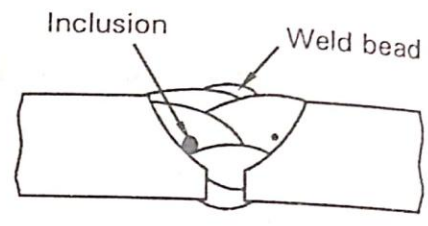
(a) Crack



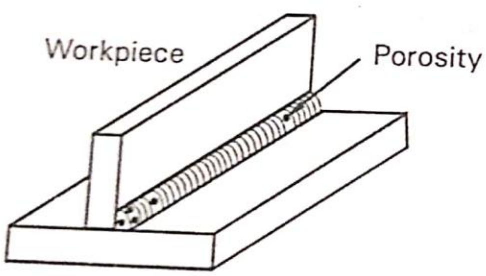
(b) Distortion



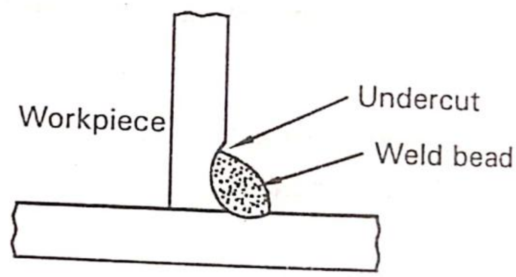
(c) Incomplete penetration



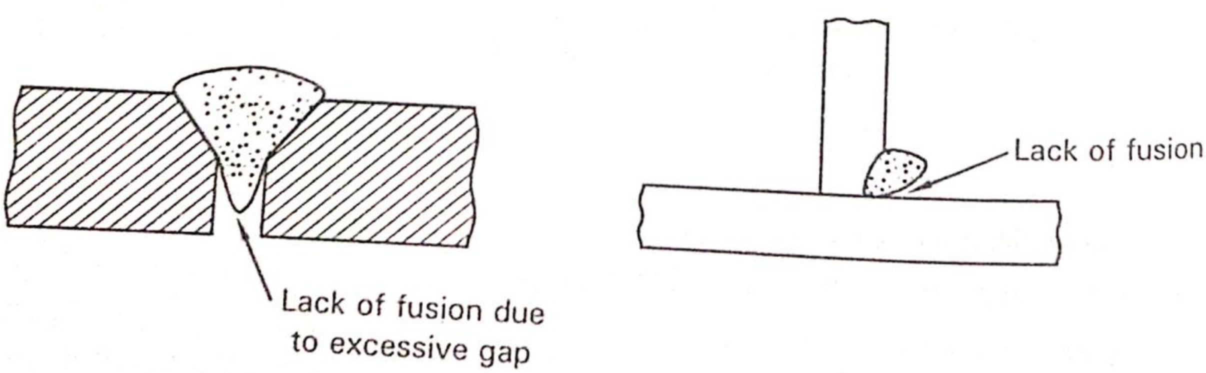
(d) Inclusion



(e) Porosity



(f) Undercut



(g) Lack of fusion

4.

Non-destructive inspection involves assessing the soundness and acceptability of the part without destroying or altering the structure of the fabricated part. Internal defects like cracks, flaws, blow holes, etc., can be effectively determined by this method. The various tests involved in this method include:

- Visual inspection
- Magnetic particle inspection
- Fluorescent particle test
- Ultrasonic inspection.
- Radiography inspection
- Eddy current inspection
- Holographic inspection etc.

5.23 ULTRASONIC INSPECTION

Ultrasonic inspection is used to detect surface and sub-surface defects in both ferrous and non-ferrous materials. Figure 5.14 shows the simplified diagram of the testing procedure.

Steps involved in the inspection process

a) The surface of the workpiece to be tested is cleaned thoroughly to remove dirt and other oxides. The transducer placed above the workpiece converts electrical energy into mechanical vibrations (sound energy), and vice-versa.

b) The sound energy from the transducer propagates through the couplant† and strikes the upper surface of the workpiece metal in the form of waves.

c) The waves from the upper surface, travel and strike the other end surface of the workpiece and will be reflected back to the transducer. In simple words, the transducer sends the waves and also receives the reflected waves.

d) The reflected waves are transformed into electrical signals by the transducer and are displayed on the CRO (cathode ray oscilloscope) screen as a sharp peak (point A).

e) When the propagating wave strikes a defect, the wave get reflected in the mid-way, back to the transducer, and as a result, an echo is displayed at point B on the CRO screen before another echo given by the wave at point C striking at the far end of the job.

f) Thus, imperfections or other conditions in the space between the transmitter and receiver reduce the amount of sound transmitted, thus revealing their presence. The echo at point B is an indication of the defect present in the workpiece.

g) Ultrasonic inspection not only helps to identify the defect, but also gives information about the location, size, distance from the surface of the workpiece, orientation and other features of the defect.

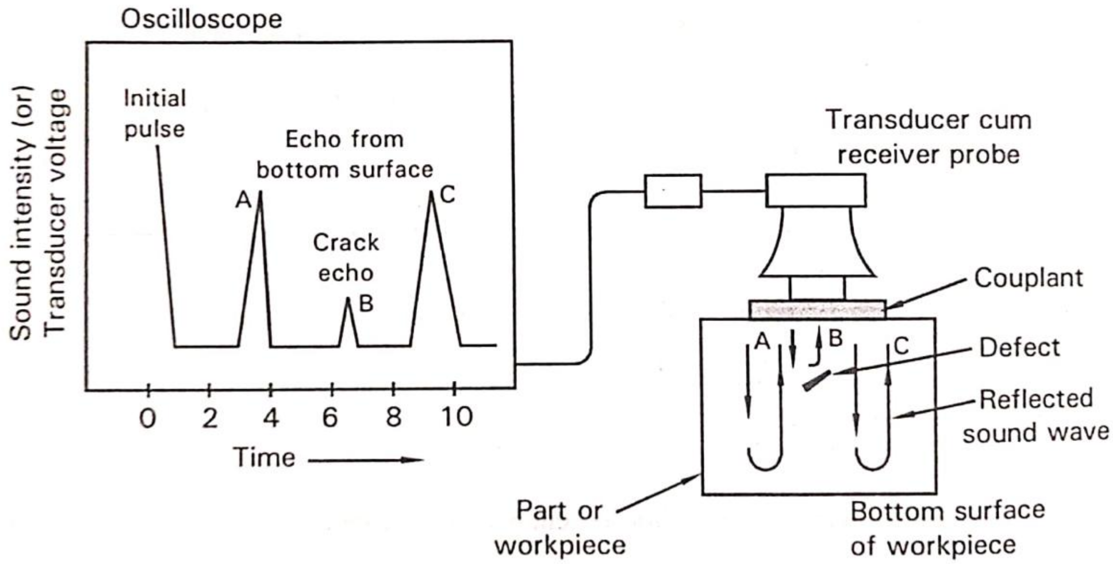


Figure 5.14 Ultrasonic inspection