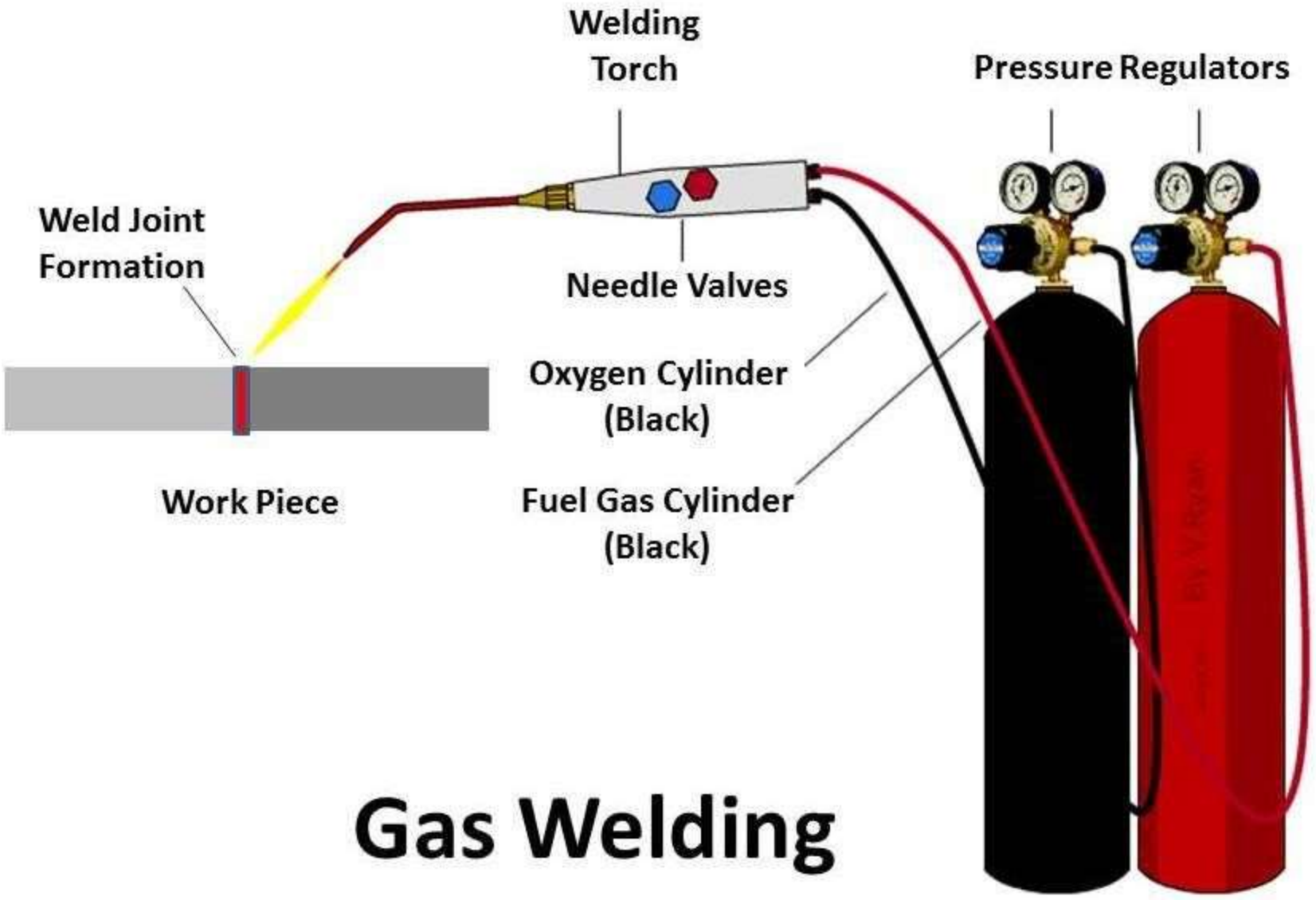
23ME715 : FABRICATION PROCESS

Dr. M Ashok Kumar
Professor
Department of Mechanical Engineering
Narsimha Reddy Engineering College (Autonomous)

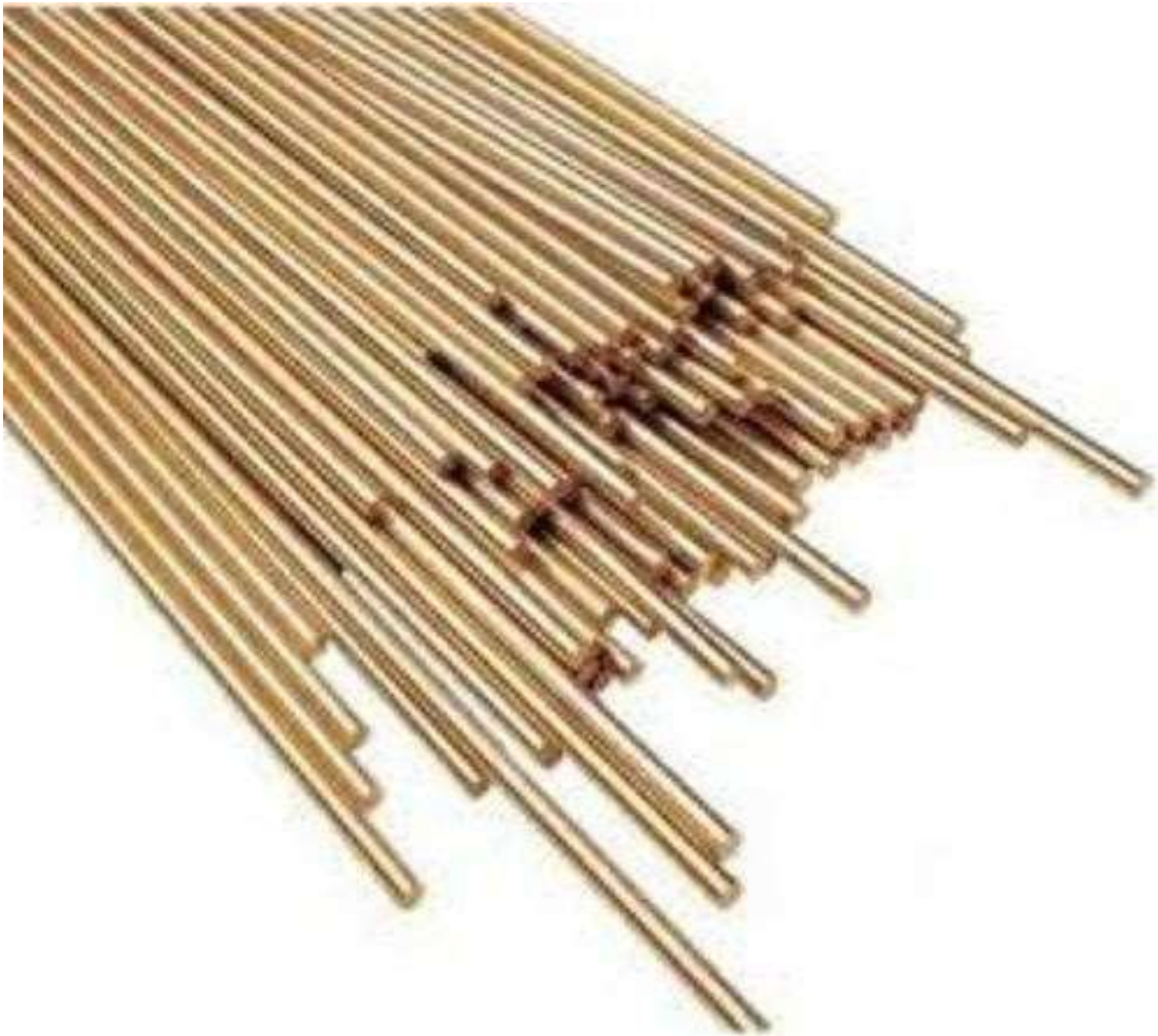
Secunderabad, Telangana, India- 500100.

UNIT-II WELDING


Welding
Torch
Pressure Regulators
Weld Joint
Formation
Needle Valves
Oxygen Cylinder
(Black)
Work Piece
Fuel Gas Cylinder
(Black)

Gas Welding

- For producing acetylene, the reaction of calcium carbide (CaC_2) with water (H_2O) is used, whereas acetylene and lime ($Ca(OH)_2$) is generated.
- an acetylene/oxygen flame produce a temperature of 3,500 °C



Oxyfuel Gas Welding

- Welding process that uses fuel gas combined with oxygen to produce flame
- This flame heat melts the metals at the joint
- Acetylene fuel is used in gas welding process

Primary combustion process

$$C_2H_2 + O_2 \longrightarrow 2CO + H_2 + heat$$

- This reaction dissociates into carbon monoxide and hydrogen.

Secondary combustion process

$$2CO + H_2 + 1.5\ O_2 \qquad 2CO_2 + H_2O + heat$$

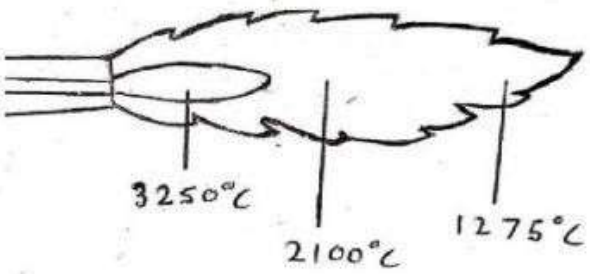
Welding Flame Types

Carburizing Flame

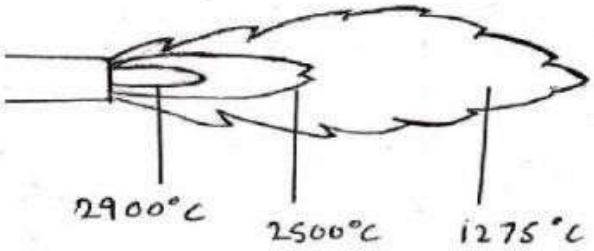
Neutral Flame

Oxidizing Flame

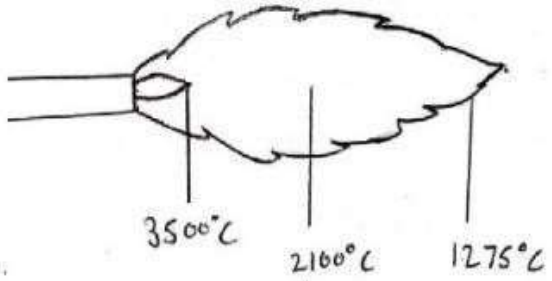
DIFFERENT TYPES OF WELDING FLAMES



Neutral or Balanced Flame



Reducing or Carburizing Flame



Oxidizing Flame

- **Gas welding is the process in which a gas flame is used to raise the temperature of the metals to be joined.**

- **The metals are heated up to melting. The metal flows and on cooling it solidifies.**

- **A filler metal may be added to the flowing molten metal to fill up cavity made during the end preparation.**

- **Welding is a fabrication process where two or more parts are fused together by means of heat.**

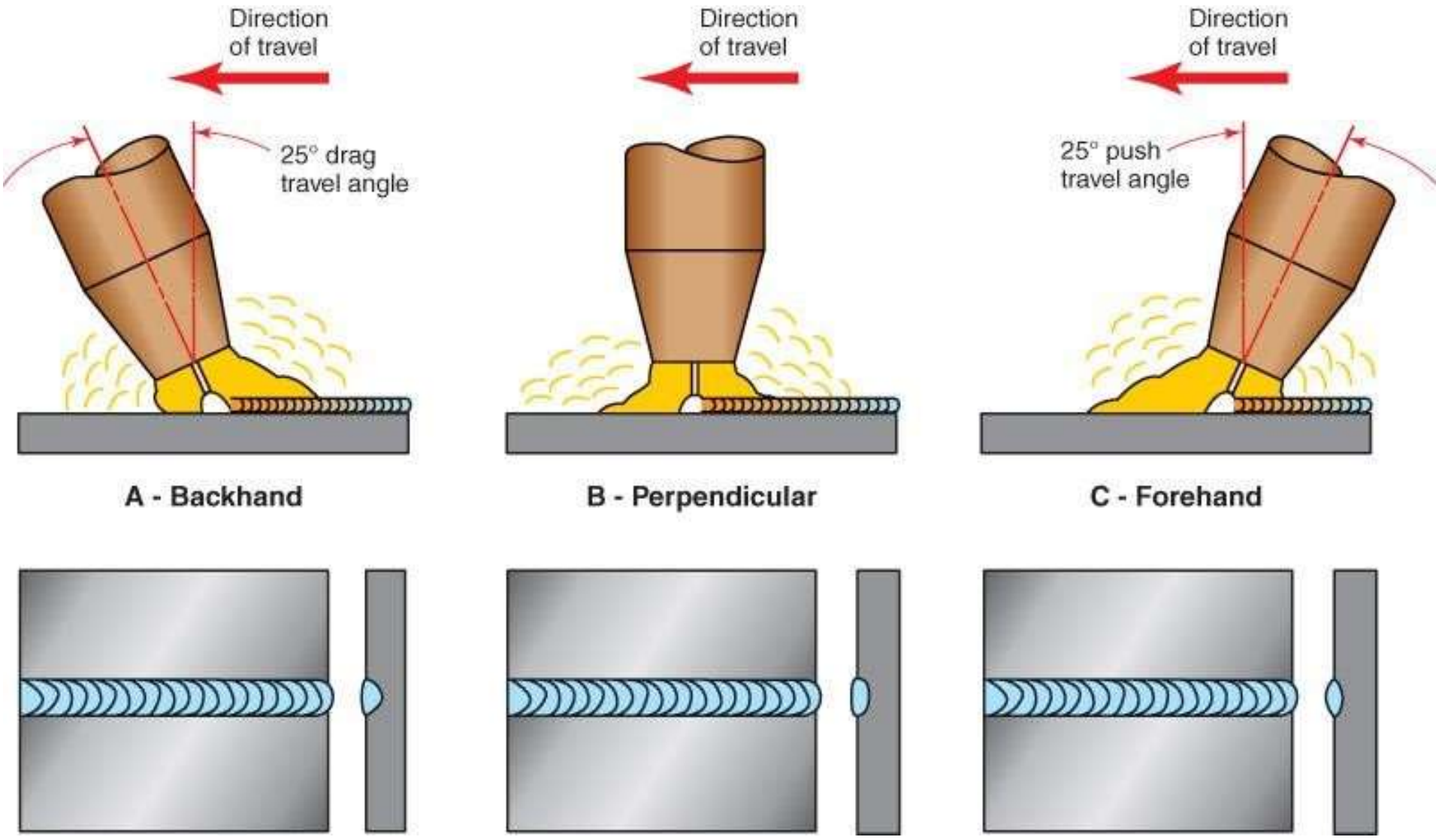
- **The completed welded joint may be called as a weldment.**

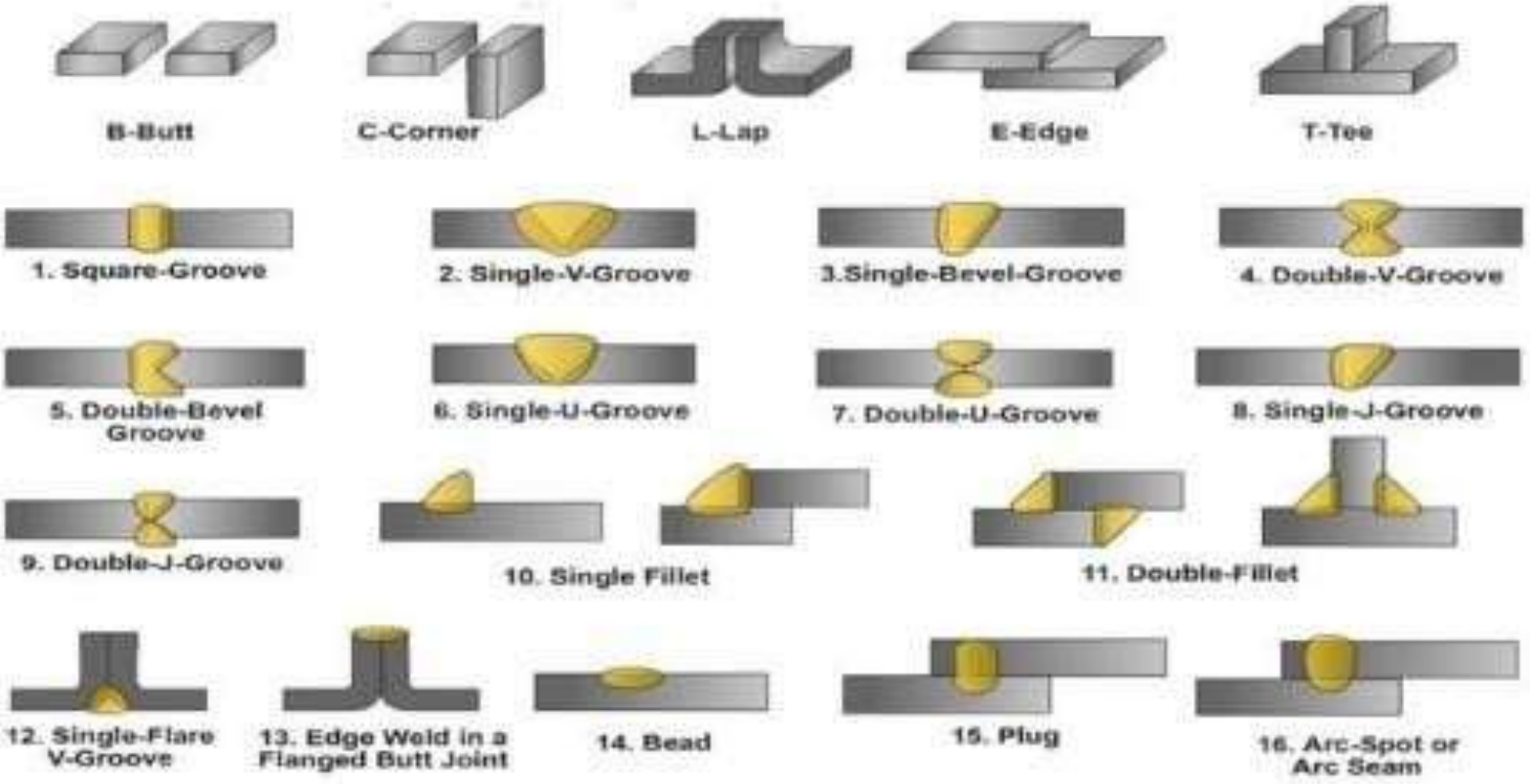
- **Applications of gas welding include welding of hot water pipes, gas bottles, nuclear heat exchangers and boilers.**

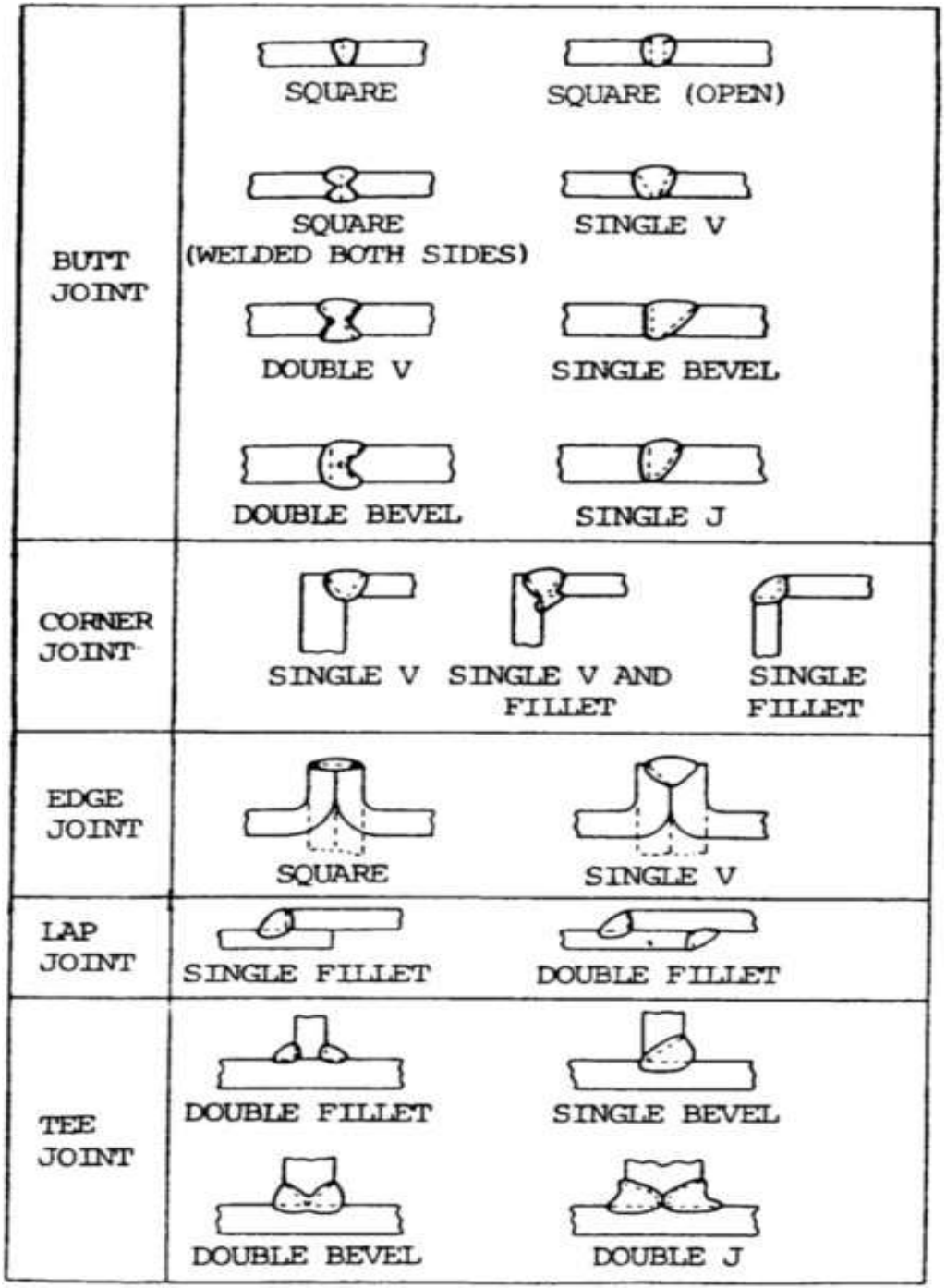
- **Slow heating and cooling can avoid the risk of hardening.**

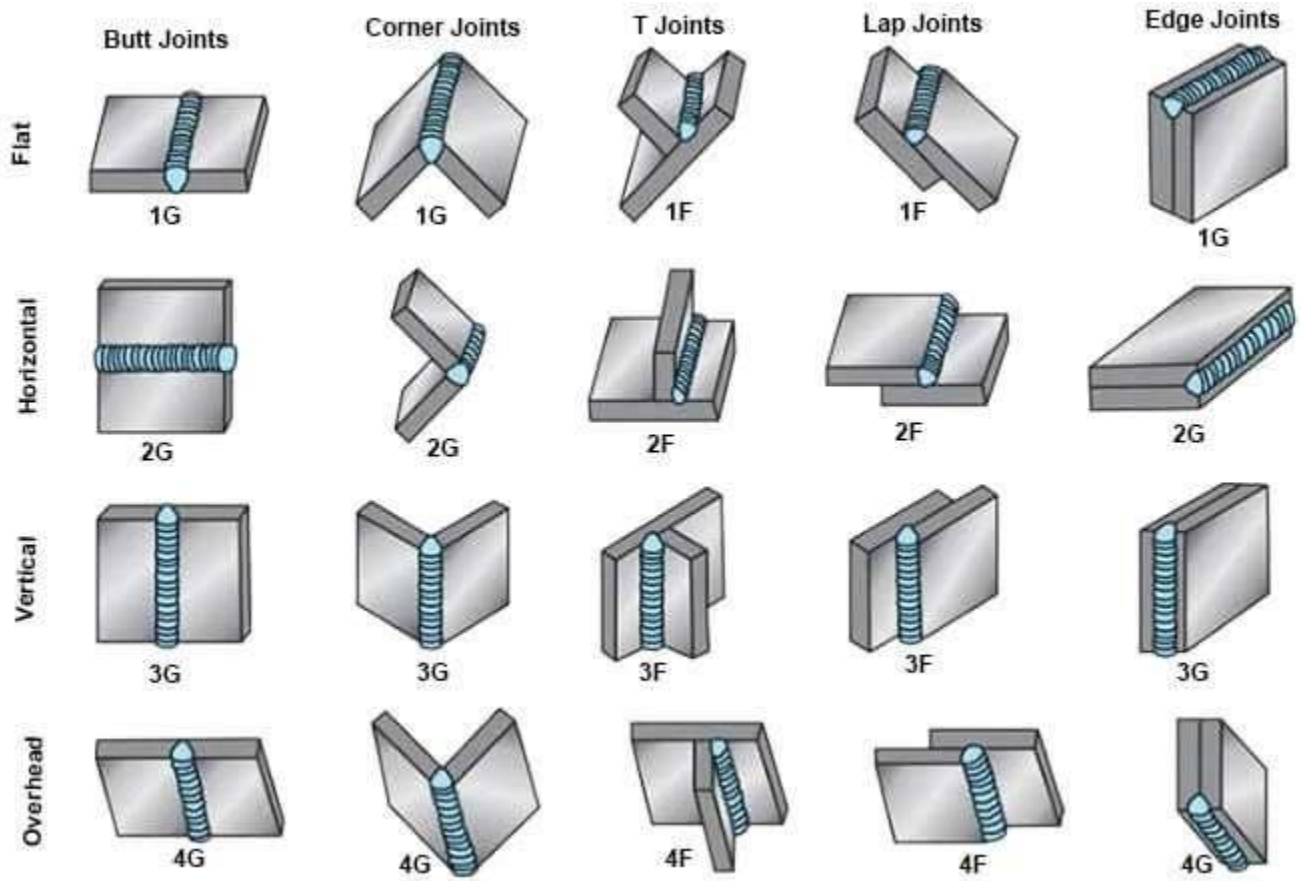
- **Oxyacetylene welding, commonly referred to as gas welding, which relies on combustion of oxygen and acetylene.**

- **When mixed together in correct proportions within a torch a relatively hot flame is produced with a temperature of about 3,200 deg. C.**


Direction of travel
25° drag travel angle
A - Backhand
Direction of travel
B - Perpendicular
Direction of travel
25° push travel angle
C - Forehand


B-Butt
C-Corner
L-Lap
E-Edge
T-Tee
1. Square-Groove
2. Single-V-Groove
3.Single-Bevel-Groove
4. Double-V-Groove
5. Double-Bevel Groove
6. Single-U-Groove
7. Double-U-Groove
8. Single-J-Groove
9. Double-J-Groove
10. Single Fillet
11. Double-Fillet
12. Single-Flare V-Groove
13. Edge Weld in a Flanged Butt Joint
14. Bead
15. Plug
16. Arc-Spot or Arc Seam

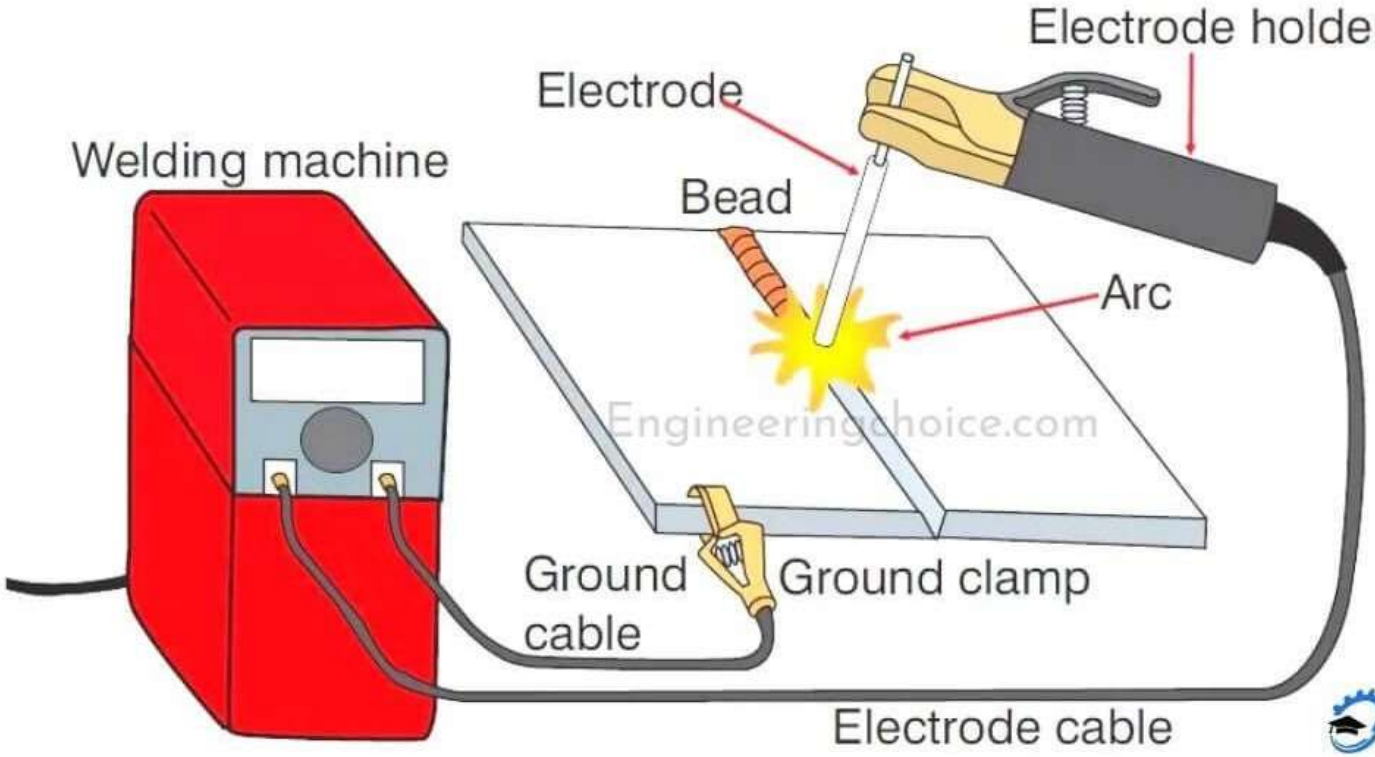

BUTT JOINT
SQUARE
SQUARE (OPEN)
SQUARE (WELDED BOTH SIDES)
SINGLE V
DOUBLE V
SINGLE BEVEL
DOUBLE BEVEL
SINGLE J
CORNER JOINT
SINGLE V
SINGLE V AND FILLET
SINGLE FILLET
EDGE JOINT
SQUARE
SINGLE V
LAP JOINT
SINGLE FILLET
DOUBLE FILLET
TEE JOINT
DOUBLE FILLET
SINGLE BEVEL
DOUBLE BEVEL
DOUBLE J


Butt Joints
Corner Joints
T Joints
Lap Joints
Edge Joints
Flat
Horizontal
Vertical
Overhead
1G
1G
1F
1F
1G
2G
2G
2F
2F
2G
3G
3G
3F
3F
3G
4G
4G
4F
4F
4G

WELDING

ARC WELDING

Arc welding is a welding process that is used to join metal to metal by using electricity to create enough heat to melt metal, and the melted metals, when cool, result in a binding of the metals.



- **Both AC and DC can be used in the arc welding.**

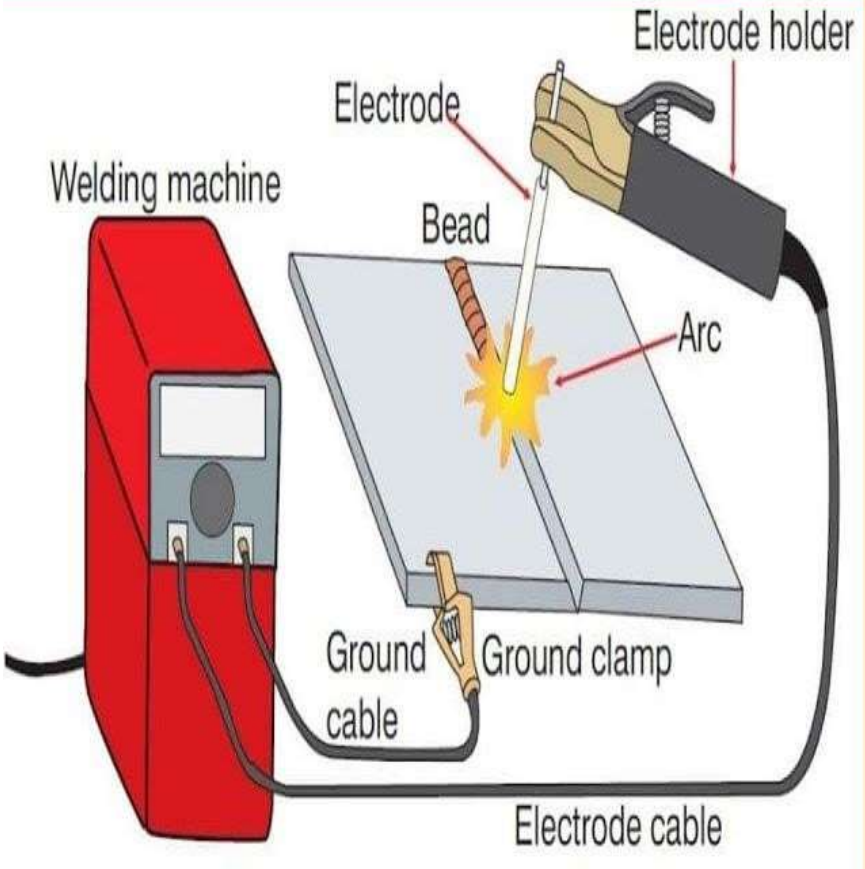
- **Usually, 70 – 100 V on AC supply**

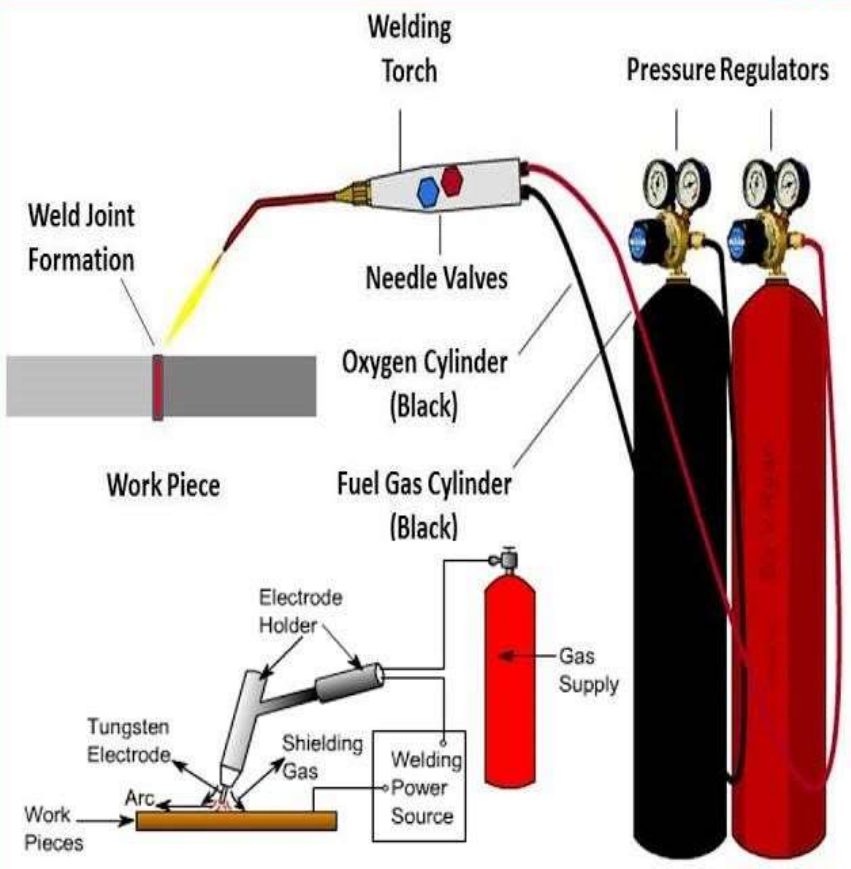
- **50 – 60 V on DC system is sufficient to strike the arc in the air gap between the electrodes.**

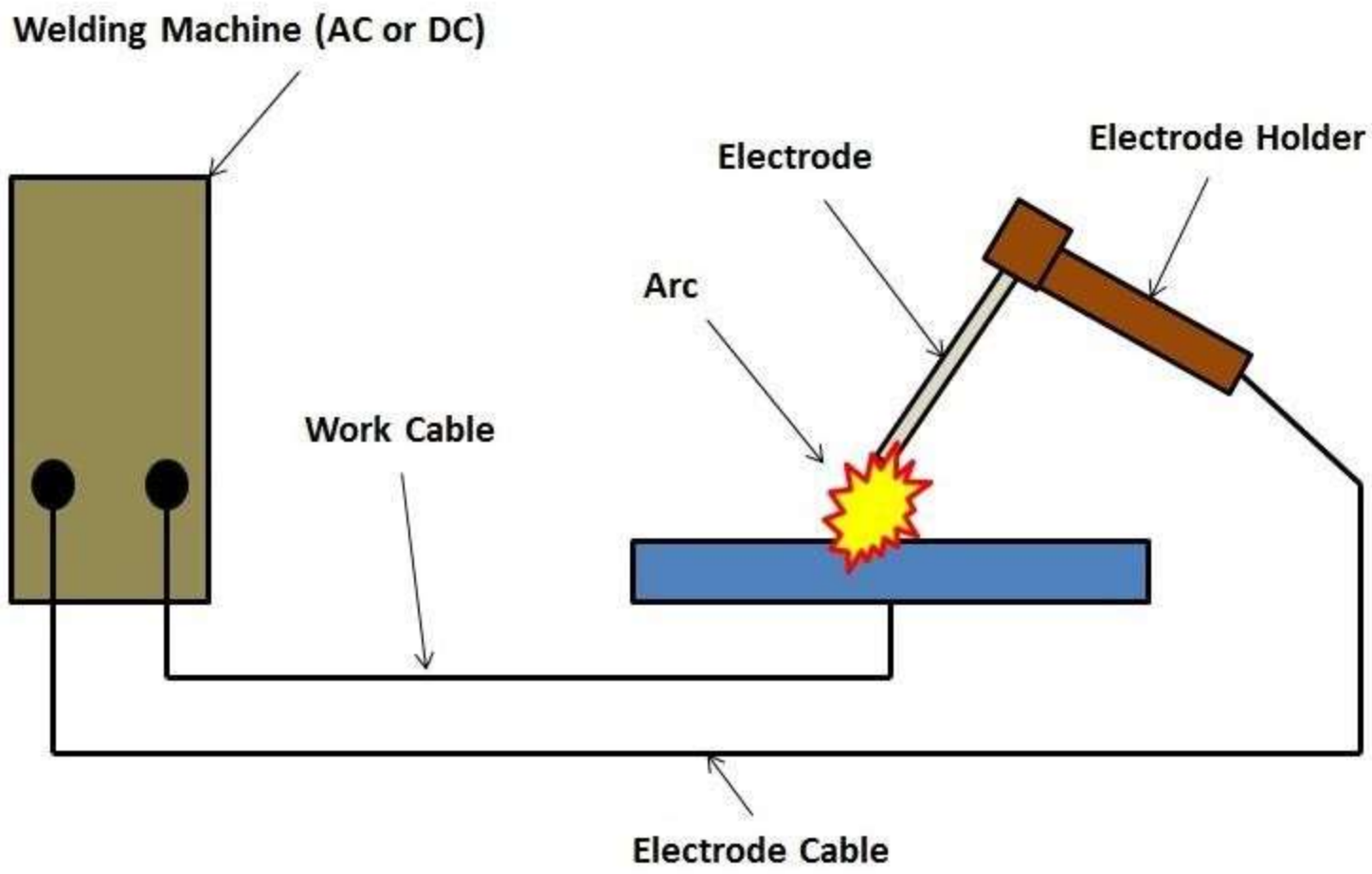
- **Once the arc is struck, 20 – 40 V is only required to maintain it.**

- **The temperature of the arc is about 5,000°C to 20,000°C.**
- **The melting temperature of iron is about 1,500°C.**
- **Consequently, the base material and electrode are heated to a high temperature and fuse together.**

Arc Welding Vs Gas Welding







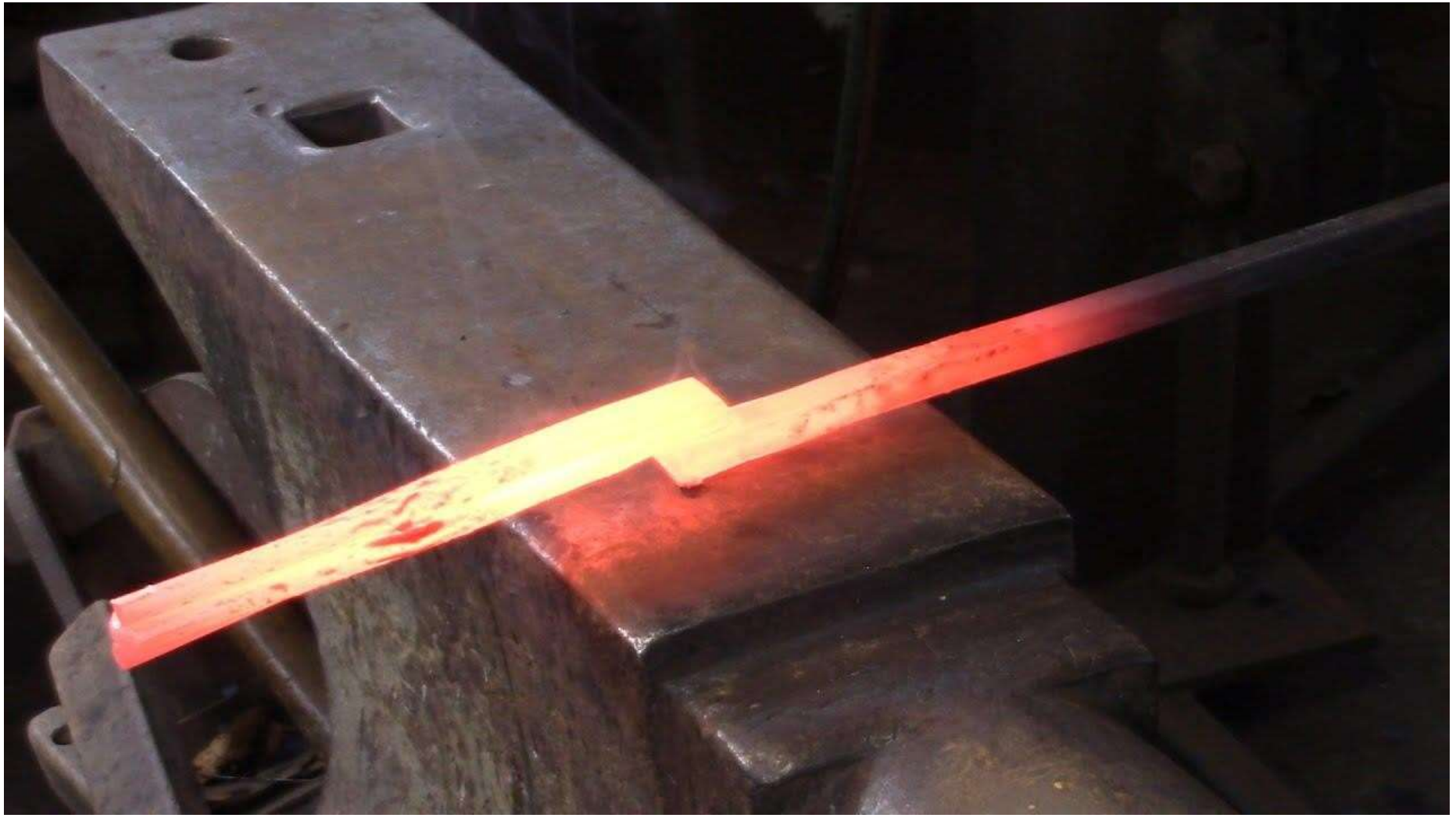
Basic Arc Welding Circuit Diagram

FORGE WELDING

- Forge welding is a process used to join two pieces of metal together by heating them to a high temperature and then hammering them together
- Welding processes are commonly used across a range of industries including aerospace, automotive, energy and construction

FORGE WELDING

FORGE WELDING



- **Forge welding is one of the oldest methods of joining metals.**
- **Forge welding is an essential technique and an invaluable skill for a blacksmith.**
- **The process requires more training from its operators given greater complexity and control of the process**

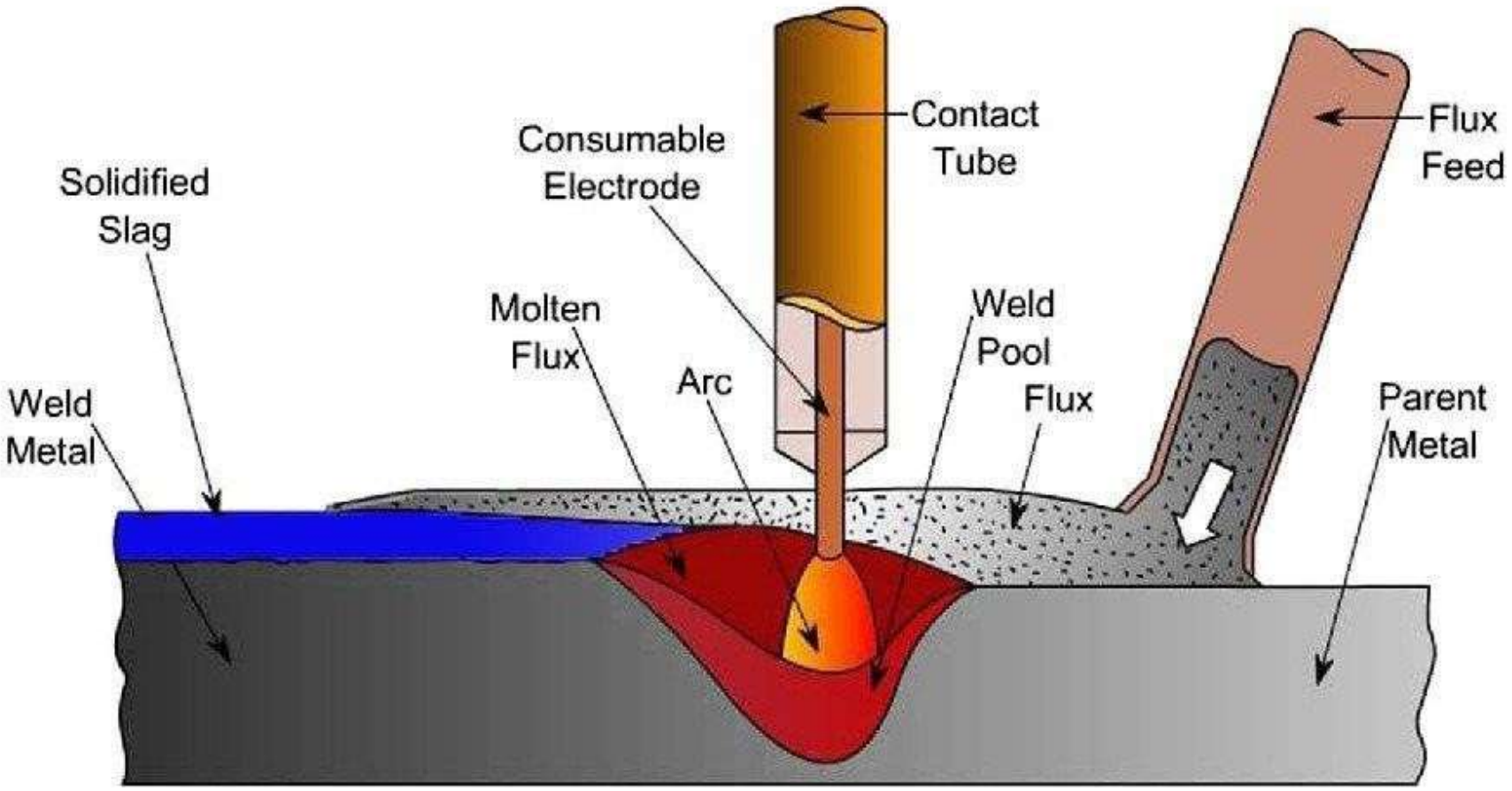
- ✓ **The diffusion bond of a forge weld is often stronger than a fusion weld (gas or arc weld) in which the metal is liquefied.**
- ✓ **The high heat combined with pressure significantly increases the strength of the material.**

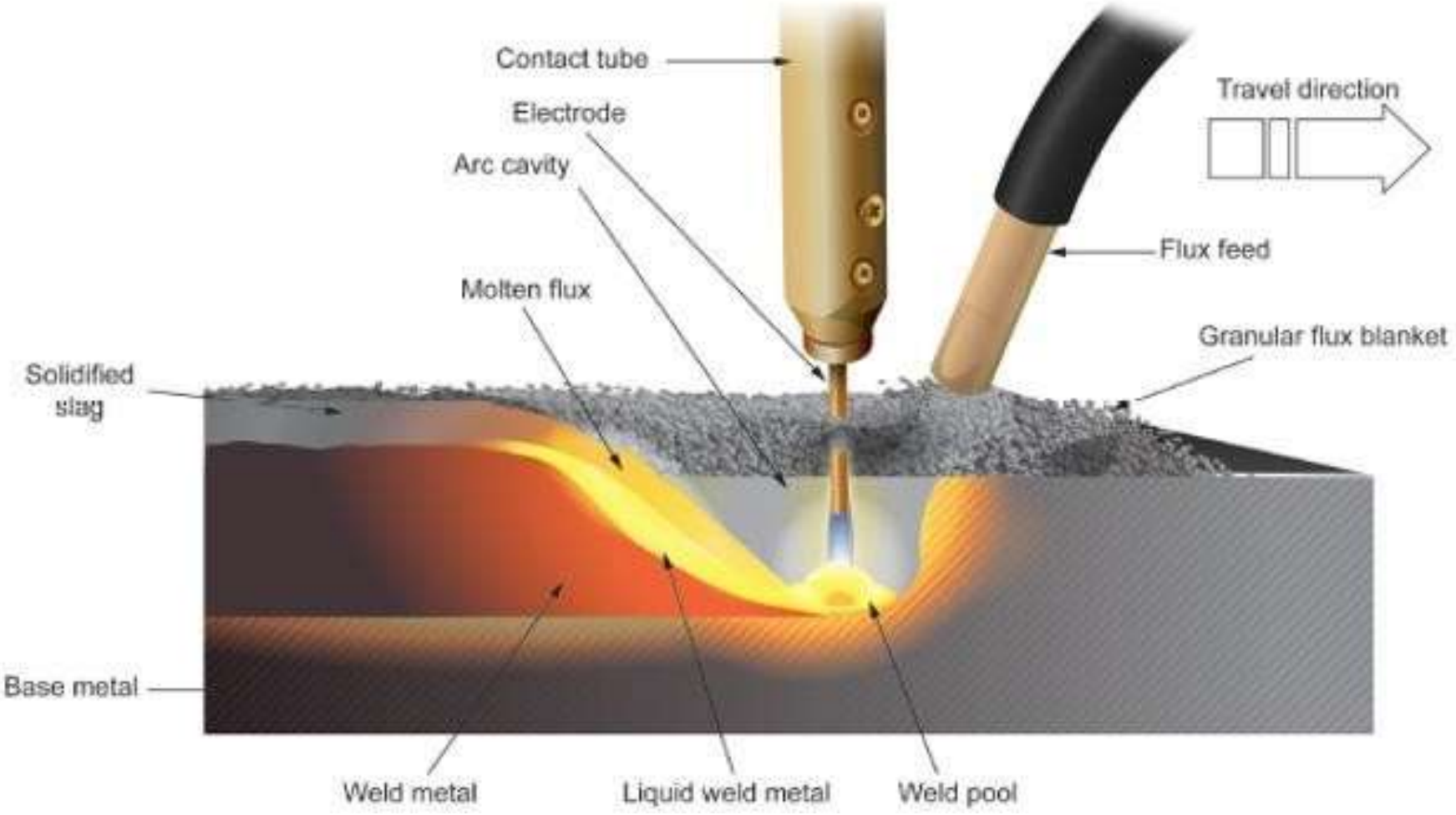
APPLICATION OF FORGE WELDING

- **Forge welding has been used throughout its history for making most any items out of steel and iron.**
- **It has been used in everything from the manufacture of tools, farming implements, and cookware to the manufacture of fences, gates, and prison cells**

SUBMERGED-ARC WELDING

- Submerged-arc welding (SAW) is a common arc welding process that involves the formation of an arc between a continuously fed electrode and the workpiece.
- The molten weld and the arc zone are protected from atmospheric contamination by being "submerged" under a blanket of granular fusible flux consisting of lime, silica, manganese oxide, calcium fluoride, and other compounds.


Solidified
Slag
Consumable
Electrode
Contact
Tube
Flux
Feed
Molten
Flux
Arc
Weld
Pool
Weld
Metal
Flux
Parent
Metal


Contact tube
Electrode
Arc cavity
Molten flux
Solidified slag
Base metal
Weld metal
Liquid weld metal
Weld pool
Travel direction
Flux feed
Granular flux blanket

ADVANTAGES

- **Extremely high deposition rates.**
- **High quality, sound, uniform welds.**
- **High speed weld Little to no fumes, arc light, spatter.**
- **Suitable for indoor or outdoor applications.**

DISADVANTAGES

- ✓**Lower efficiency – more waste is generally produced during arc welding than many other types, which can increase project costs in some cases.**
- ✓**High skill level – operators of arc welding projects need a high level of skill and training, and not all professionals have this.**

APPLICATIONS

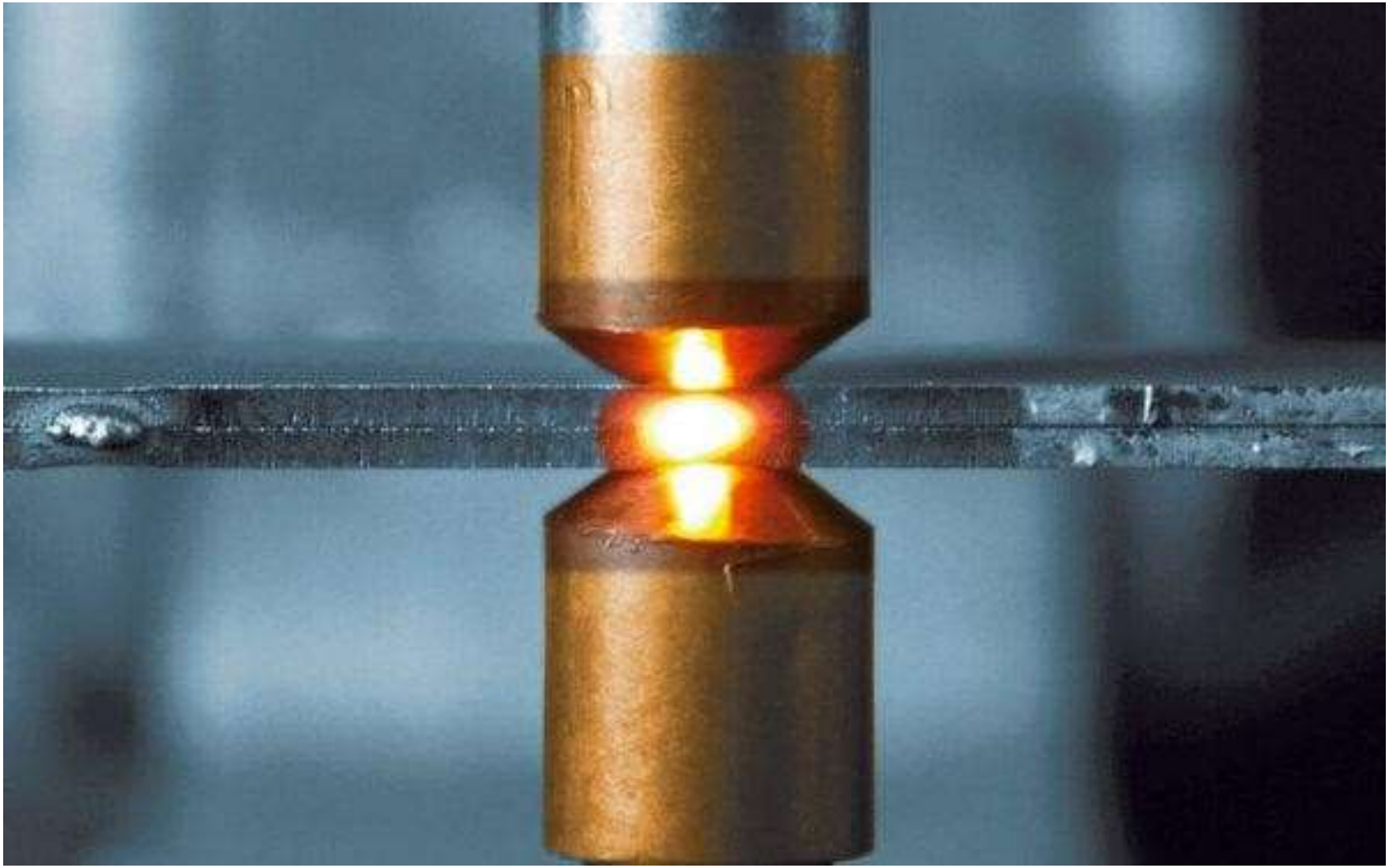
- ✓ It is used for welding of low alloy steels.
- ✓ It is also used for stainless steels and nickel based alloys.
- ✓ It can also be used for surfacing applications such as wear-facing, corrosion overlay of steels, etc.

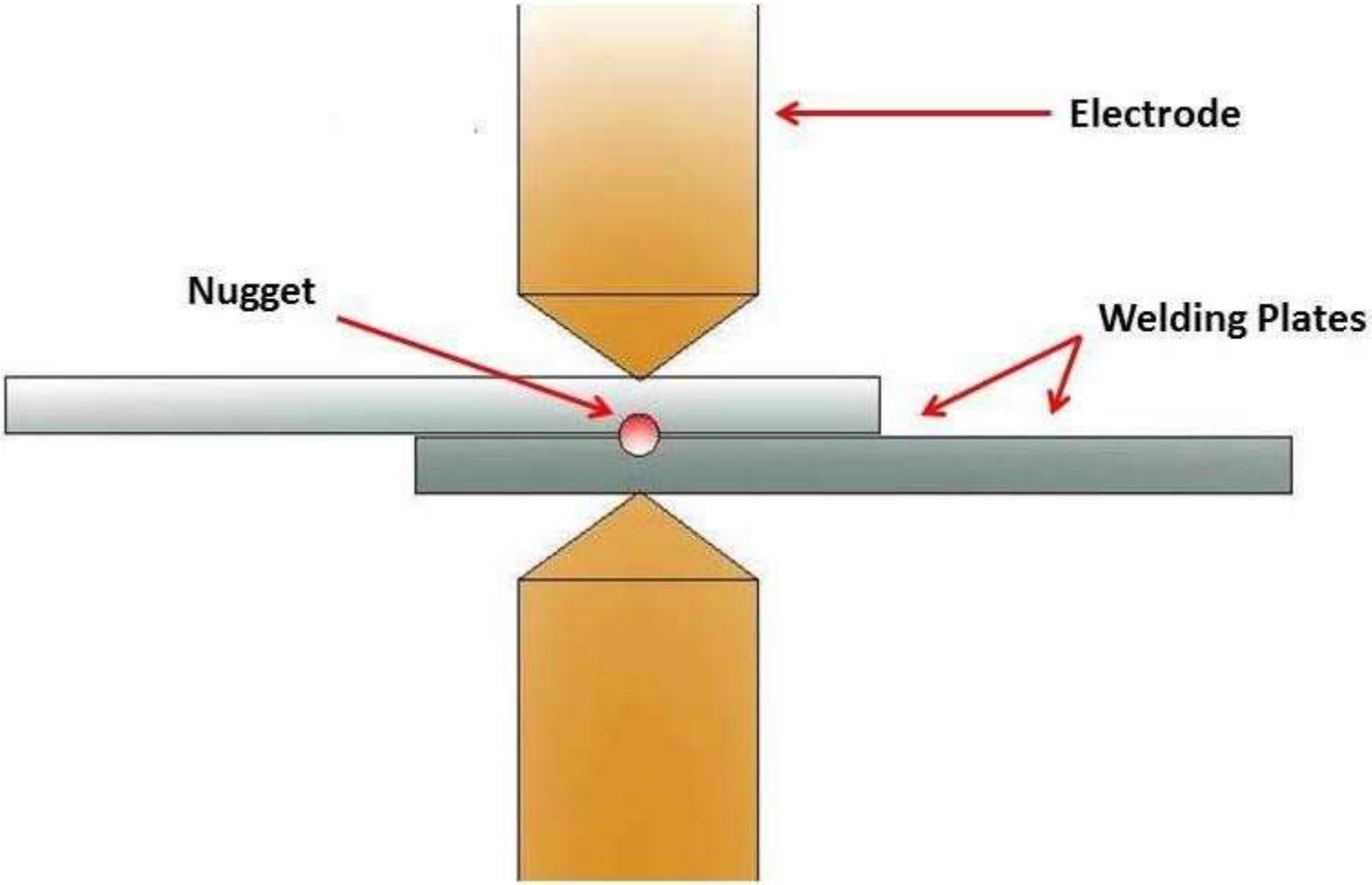
SPOT WELDING

- **Spot welding is also known as resistance spot welding .**

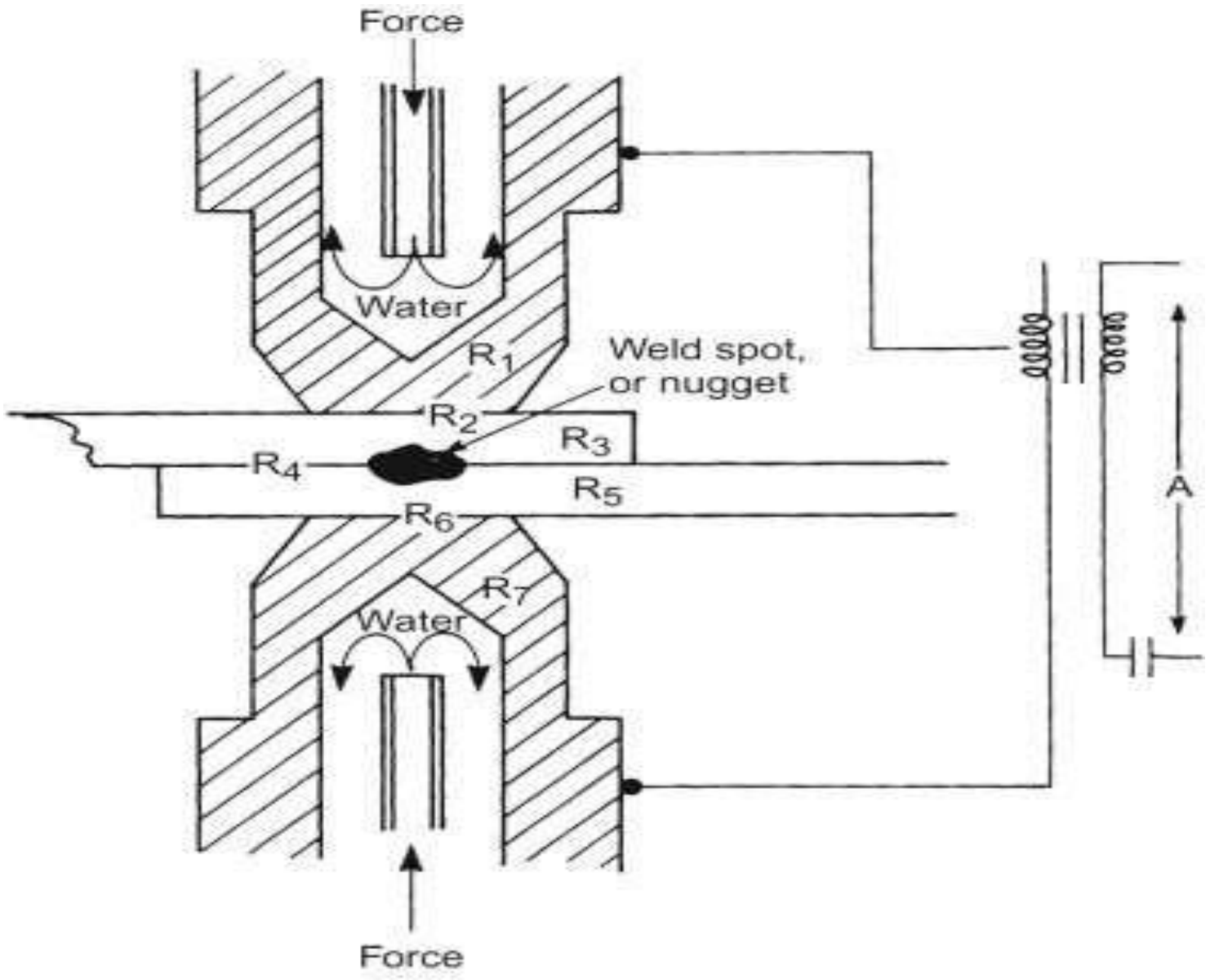
- **This welding process is used primarily for welding two or more metal sheets together by applying pressure and heat from an electric current to the weld area.**

- **It's called spot welding because this welding method creates a tiny dot weld, that looks like a spot. The weld created between the copper electrodes is also sometimes called a nugget.**





Spot Welding


Force
Water
R1
Weld spot,
or nugget
R2
R3
R4
R5
R6
R7
Water
Force
A

- **Electrodes seated in a weld head are brought to the surface of the parts to be joined and force (pressure) is applied.**

- **Current is applied through the electrodes to the workpiece to melt the material.**

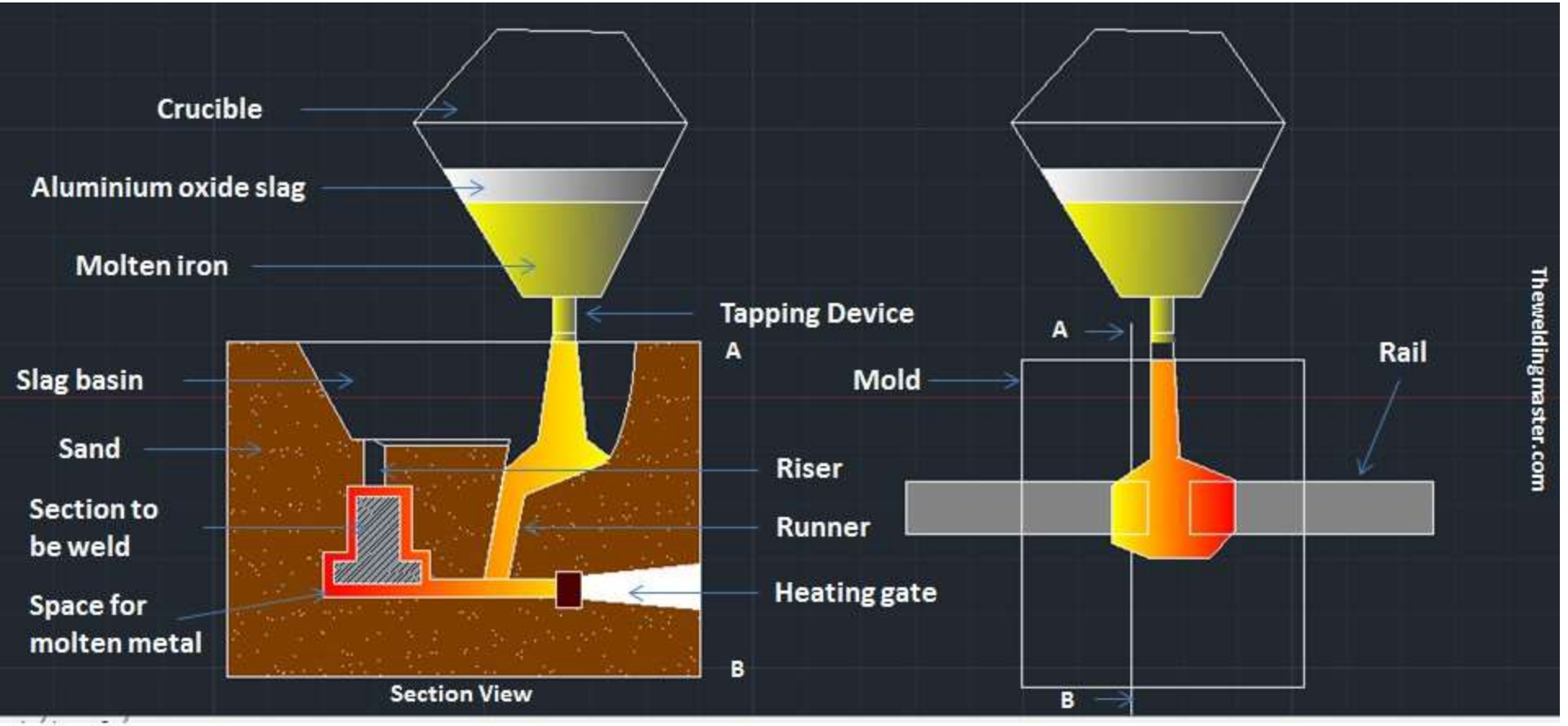
- **Current is removed but electrodes remain in place at force to allow the material to cool and solidify.**

THERMIT WELDING

- **Thermit welding (TW) is a process that uses heat from an exothermic reaction to produce coalescence between metals.**

- **The name is derived from 'thermite' the generic name given to reactions between metal oxides and reducing agents.**

- **It is used to repair steel castings and forgings, for joining railroad rails, steel wires and steel pipes, for joining the large cast and forged parts**



Thermit Welding Process

- **Thermit welding is a process where heat generated from an exothermic chemical reaction.**

- **The chemical reaction occurs between aluminum powder and metal oxide.**

- **This reaction generates a molten metal that acts as filler metal joining the workpieces on solidification.**

Thermit Welding on Railway Track

- ✓ **The process of igniting Aluminium and Ferric oxide is called thermite reaction.**

- ✓ **This is an exothermic reaction.**

- ✓ **Iron obtained in this process is in molten state.**

- ✓ **Fe_2O_3 (s) + Al (s) → Al_2O_3 + 2 Fe(l) + Heat.**

- ✓ **The reaction is ignited by burning a magnesium ribbon**

- **Aluminium has a high affinity for oxygen.**

- **It readily removes oxygen from oxides of less reactive metals so it is used in thermite welding.**

- **The thermite mixture is a combination of finely powdered aluminum and iron oxide (also called ferric oxide) in a mass ratio of 1:3 respectively**

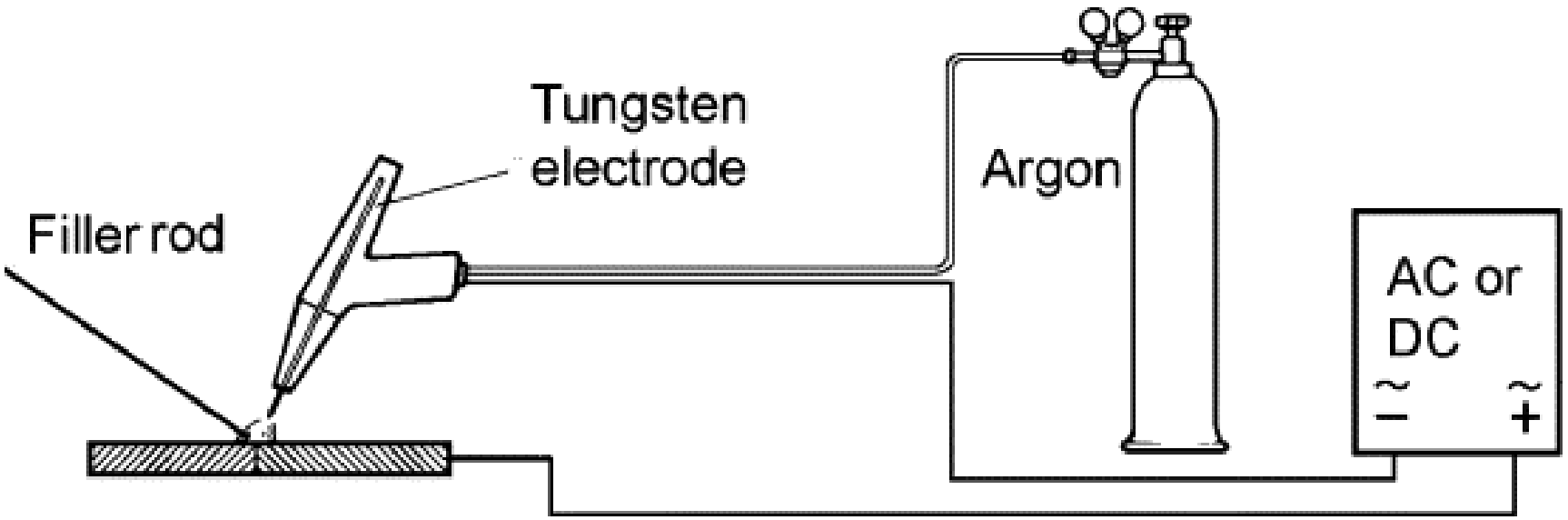
- **Thermite process is exceptionally helpful for the welding of broken metal parts.**

INERT GAS WELDING

- **The inert gas serves a great purpose in shielding the atmosphere while welding.**
- **Argon is being dispersed straight through the tip of the welder, surrounding the arc and thus limiting the effect of moisture and other elements that otherwise may make the weld brittle, uneven or create spores in it.**

- **The inert gas include argon, hydrogen, and helium.**
- **Helium is generally added to increase the heat input, which increases the welding speed.**
- **Noble gases are known as inert gases because of their reluctance to combine with other elements to form compounds.**
- **These gases are also called shielding gases.**

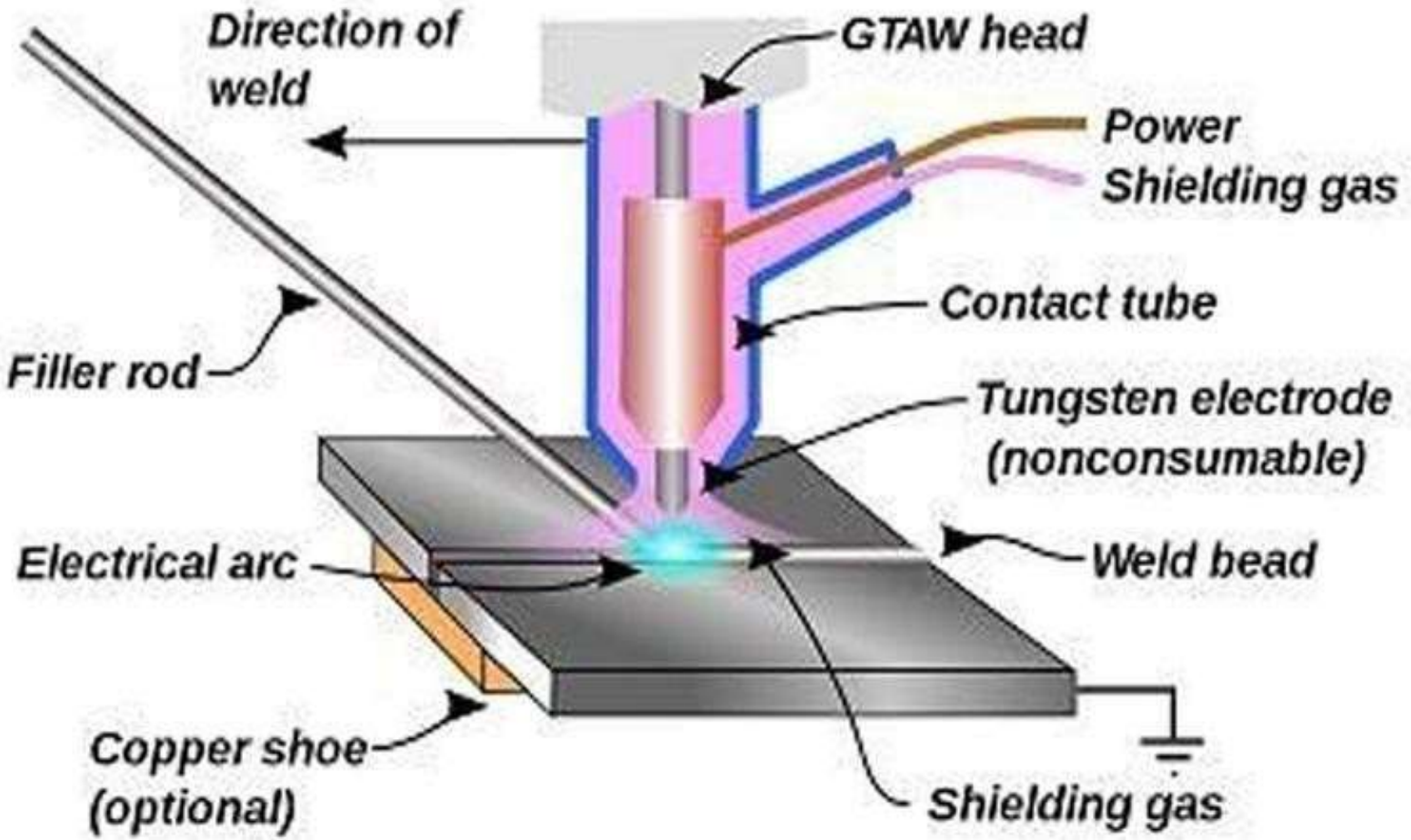
INERT GAS WELDING



TIG WELDING

- **Tungsten Inert Gas (TIG) welding, also known as Gas Tungsten Arc Welding (GTAW) is an arc welding process that produces the weld with a non-consumable**

- **DC is used for TIG welding Mild Steel/Stainless material and AC would be used for welding Aluminium.**


Direction of weld
GTAW head
Power
Shielding gas
Contact tube
Filler rod
Tungsten electrode (nonconsumable)
Electrical arc
Weld bead
Copper shoe (optional)
Shielding gas

- **TIG welders can be used to weld steel, stainless steel, aluminum, nickel alloys, magnesium, copper, brass, bronze, and even gold.**
- **TIG is a useful welding process for welding wagons, bike frames, lawn mowers, door handles, etc.**
- **DC is used for TIG welding Mild Steel/Stainless material and AC would be used for welding Aluminium.**

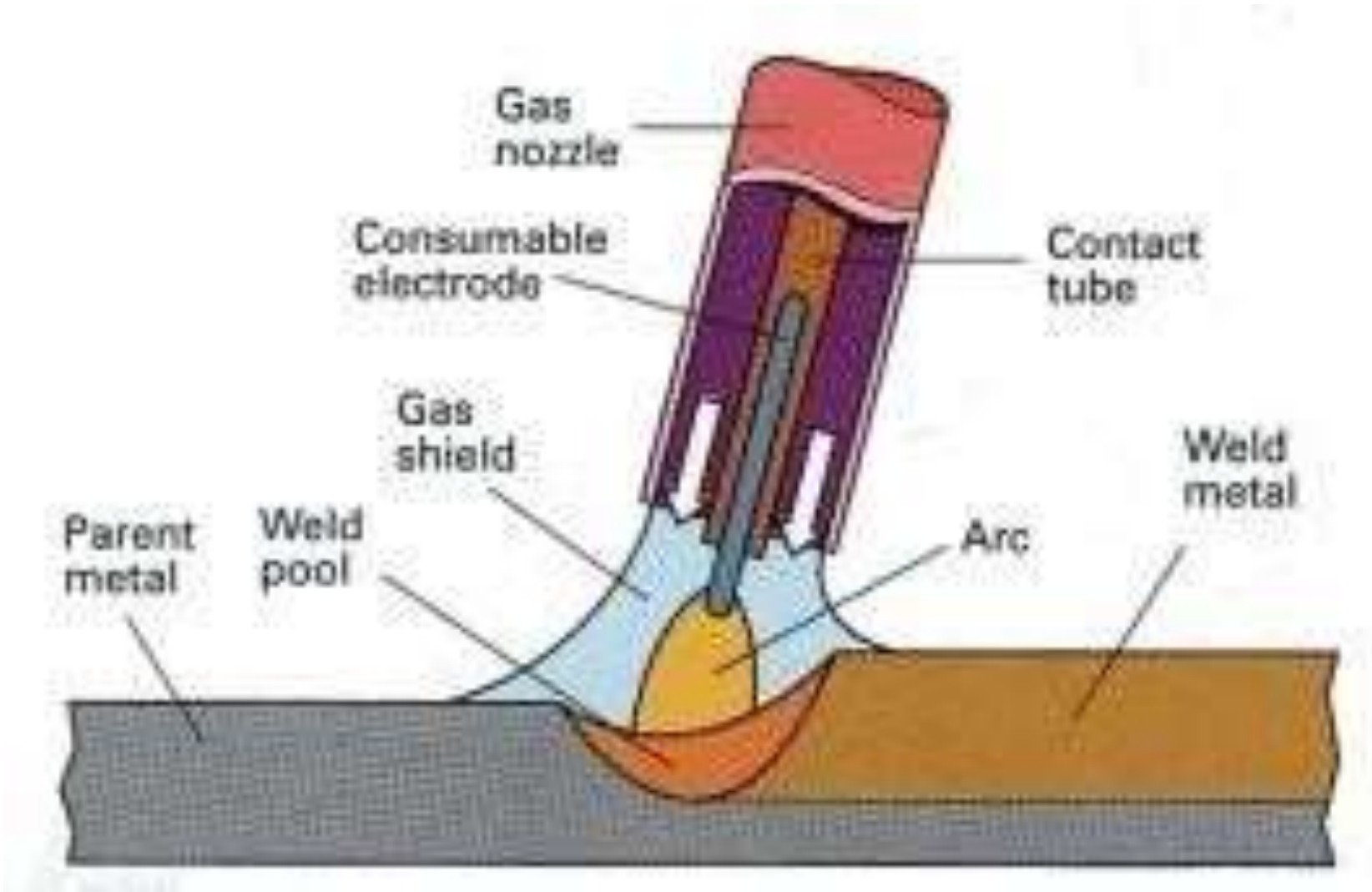
- **TIG welding is often considered the strongest weld since it produces extreme heat, and the slow cooling rate results in high tensile strength and ductility.**

- **TIG is the better option for welding aluminum because it allows for better results on lighter gauge materials.**

- **TIG welding is often considered the strongest weld since it produces extreme heat, and the slow cooling rate results in high tensile strength and ductility.**
- **TIG welds are better for thinner metals and smaller projects because they produce precise and clean welds.**

MIG welding

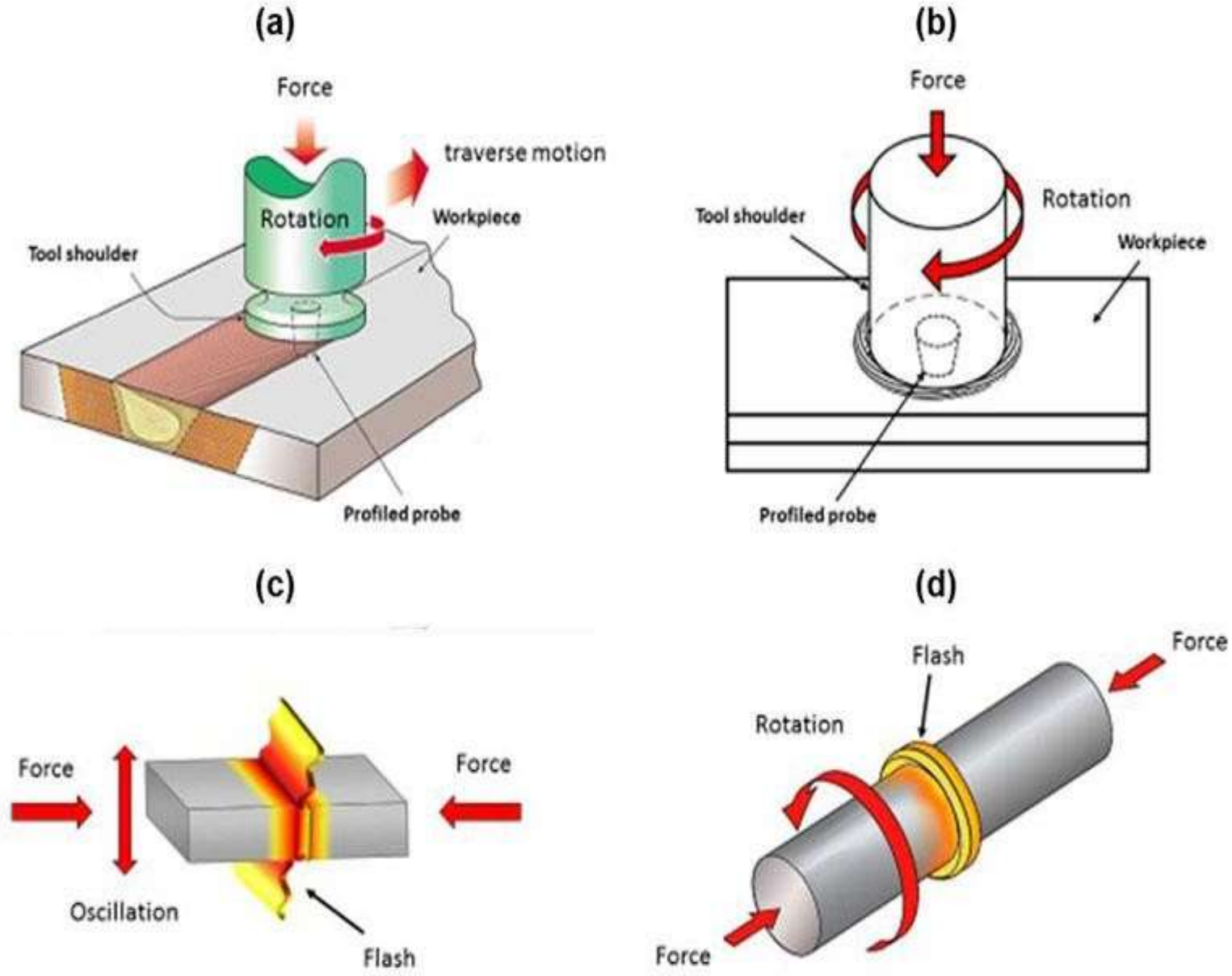
- **Metal Inert Gas (MIG) welding is an arc welding process that uses a continuous solid wire electrode heated and fed into the weld pool from a welding gun.**
- **Metal inert gas—welding is generally used for large and thick materials. It employs a consumable wire that acts as both the electrode and the filler material.**

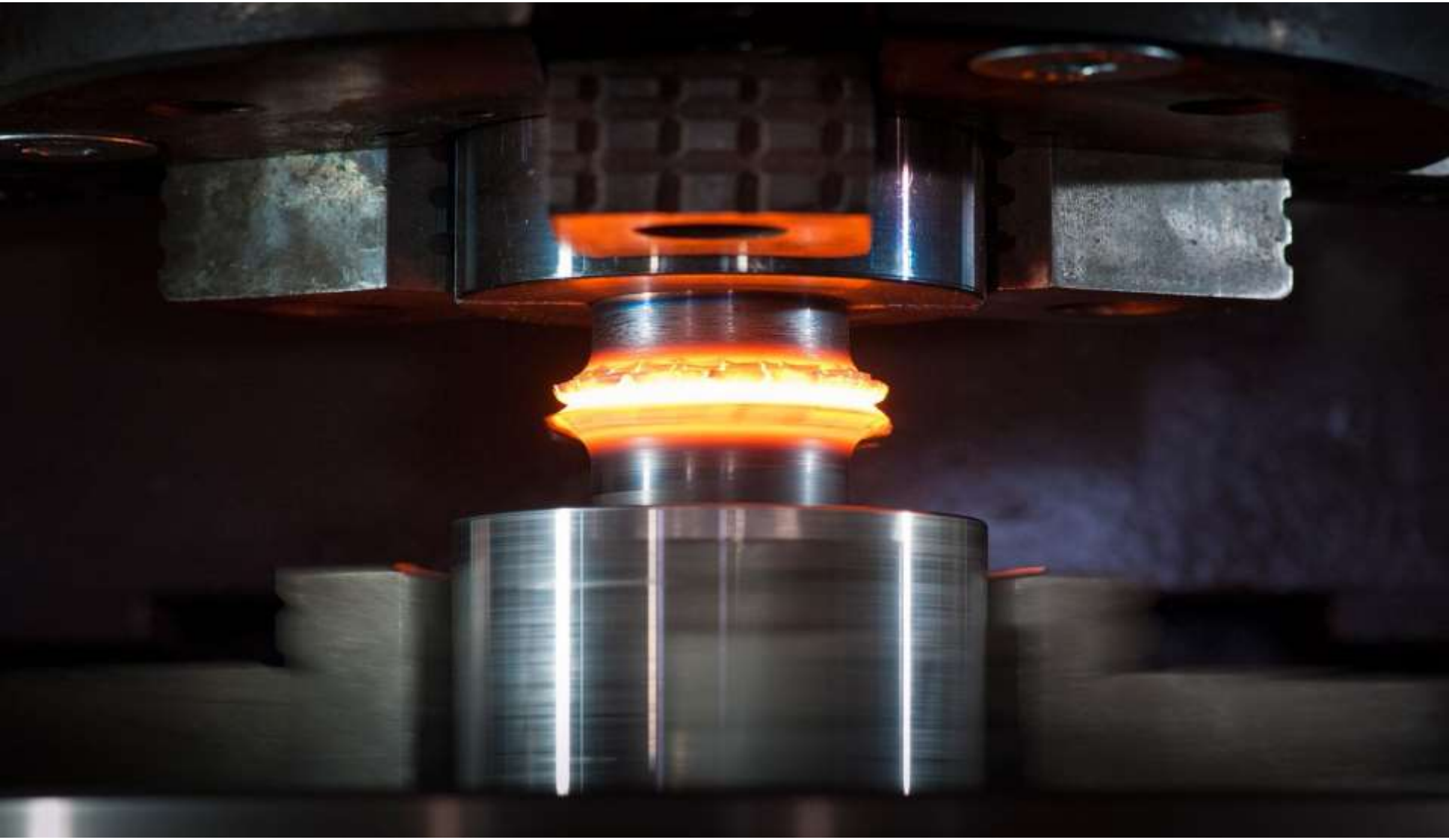

Gas nozzle
Consumable electrode
Contact tube
Gas shield
Weld metal
Parent metal
Weld pool
Arc

- **MIG uses a solid wire that is machine-fed to the weld area while TIG uses a non-consumable electrode and a hand-held filler rod to form the weld.**
- **MIG welds work well with larger projects with thick metals that need longer, continuous runs.**

FRICTION WELDING (FRW)

- **Friction welding (FRW) is a class of solid-state welding processes, in which heat is generated by mechanical friction between a moving component and a stationary one, and at the same time a lateral force called 'upset' is applied to the parts, in order to plastically displace and fuse the material.**


(a)
Force
traverse motion
Rotation
Workpiece
Tool shoulder
Profiled probe
(b)
Force
Rotation
Tool shoulder
Workpiece
Profiled probe
(c)
Force
Force
Oscillation
Flash
(d)
Flash
Force
Rotation
Force



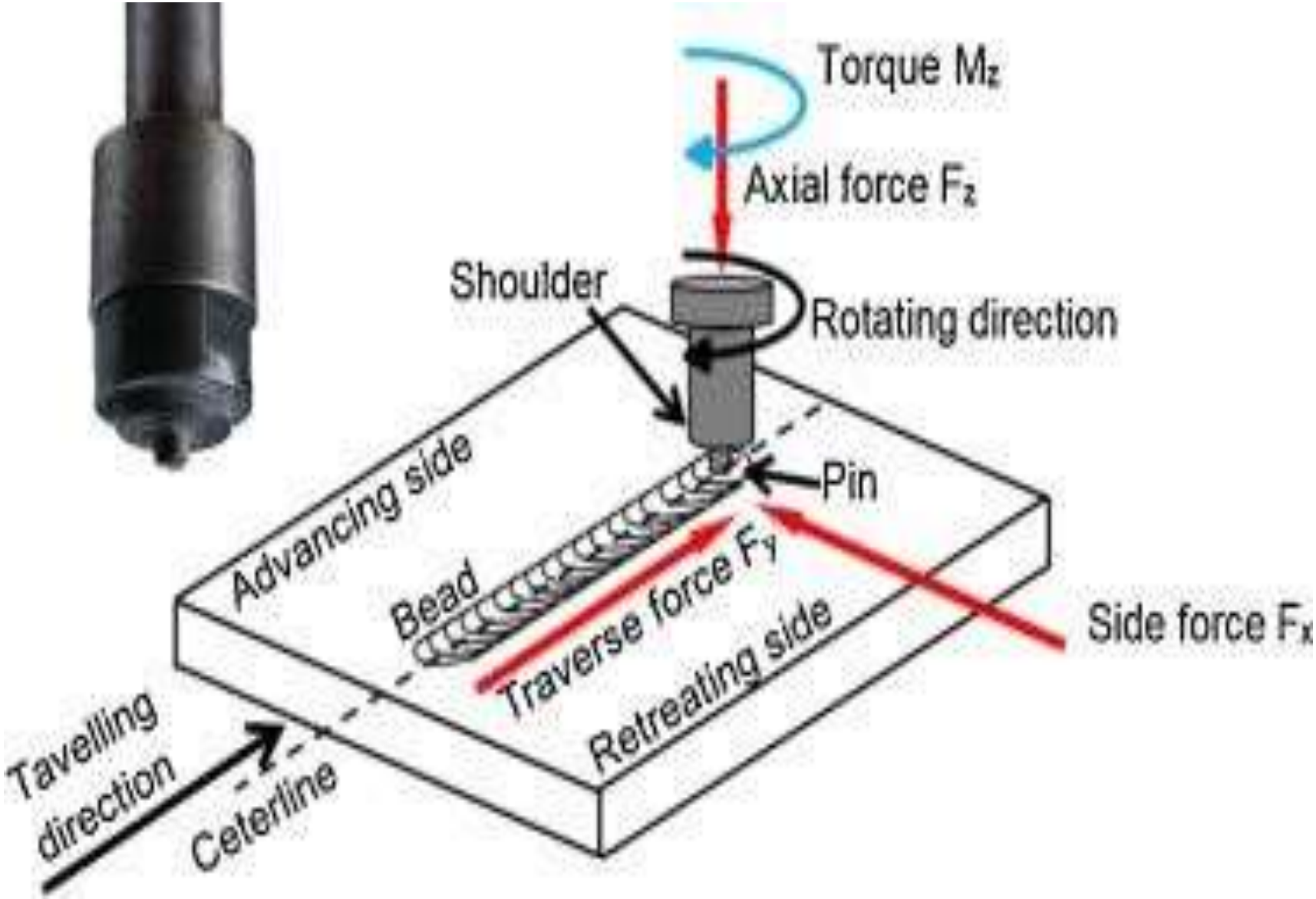
- **Friction welding can be used to build better industrial rollers, tubes, and shafts.**
- **Friction stir processing (FSP) is a method of changing the properties of a metal through intense, localized plastic deformation.**
- **In FSP deformation is produced by forcibly inserting a non-consumable tool into the workpiece, and revolving the tool in a stirring motion as it is pushed laterally through the workpiece.**

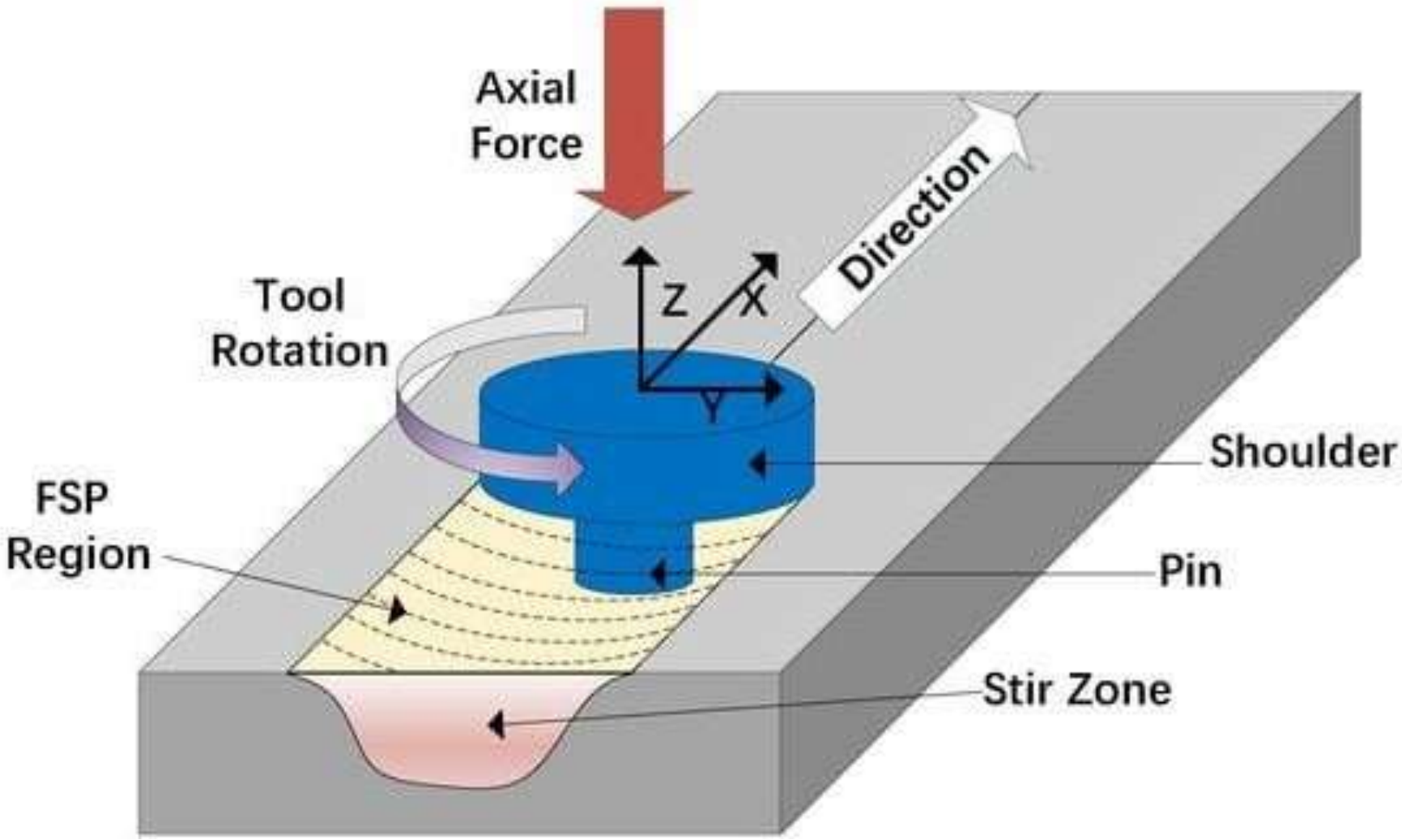
DISADVANTAGES

- As it is a solid state process, a great amount of tool wear takes place during the plunging stage as the work piece material is cold at this time.
- Weld speeds in FSW are slower which can lead to time-consuming joining process.

Benefits of Friction Stir Welding

- No need for filler wire or shielding gas.
- Improved safety due to the absence of toxic fumes and molten splatter.
- Lower setup costs and less training.


Torque Mz
Axial force Fz
Shoulder
Rotating direction
Advancing side
Pin
Bead
Traverse force Fy
Side force Fx
Retreating side
Tavelling direction
Celterline


Axial
Force
Direction
Z
X
Y
Tool
Rotation
Shoulder
FSP
Region
Pin
Stir Zone

- **Friction stir welding delivers higher joint strength compared to common fusion welding**

- **The consistency is higher.**

- **No filler material, preheating or shielding gas is used.**

- **FSW leaves a neat and clean appearance that normally does not require any rework.**

- **Defect free welds are achieved in rotational speed range of 400–1500 rpm.**

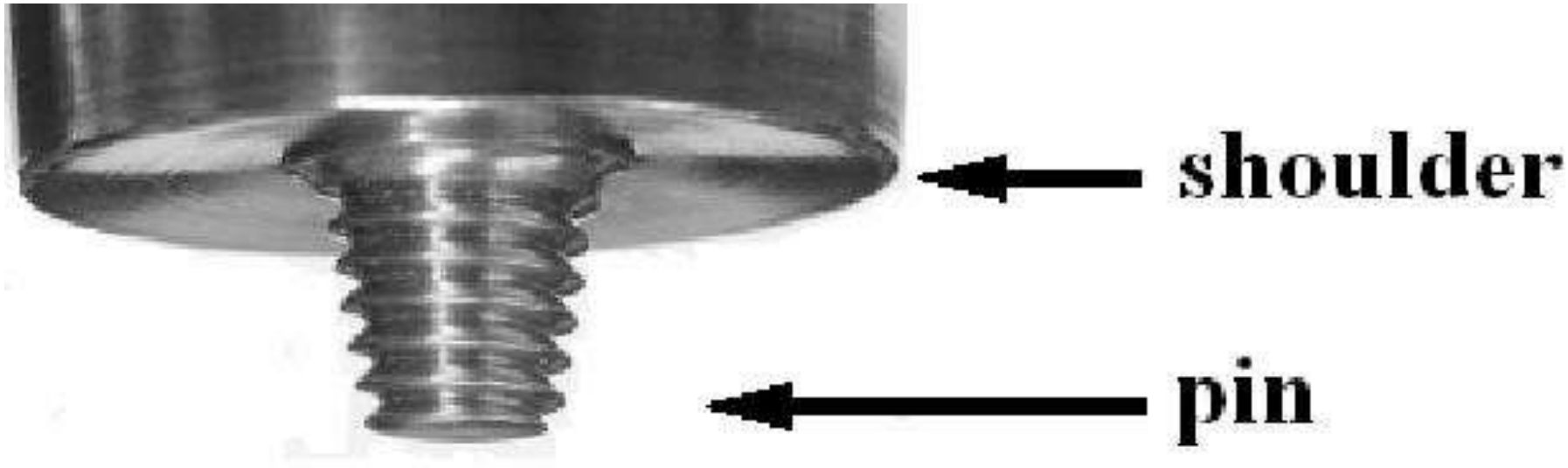
- **FRW can join both similar and dissimilar material**

- **FSW is primarily used for joining Aluminium Alloys.**

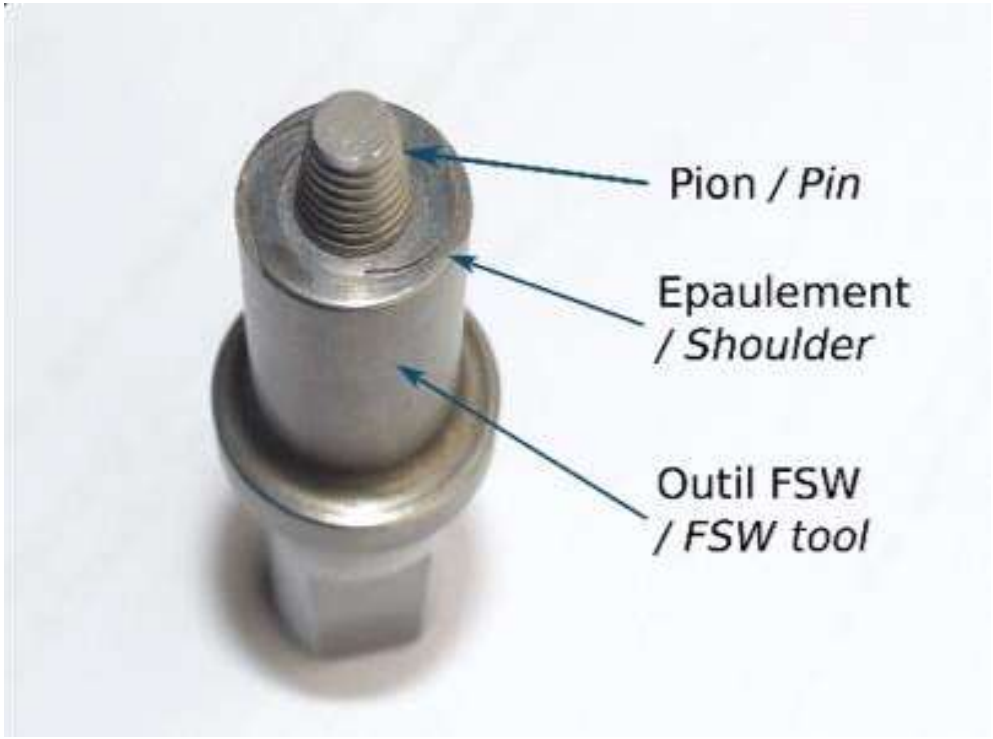
- **FRW does not produce any heat affected zones (HAZ) like fusion welding,**

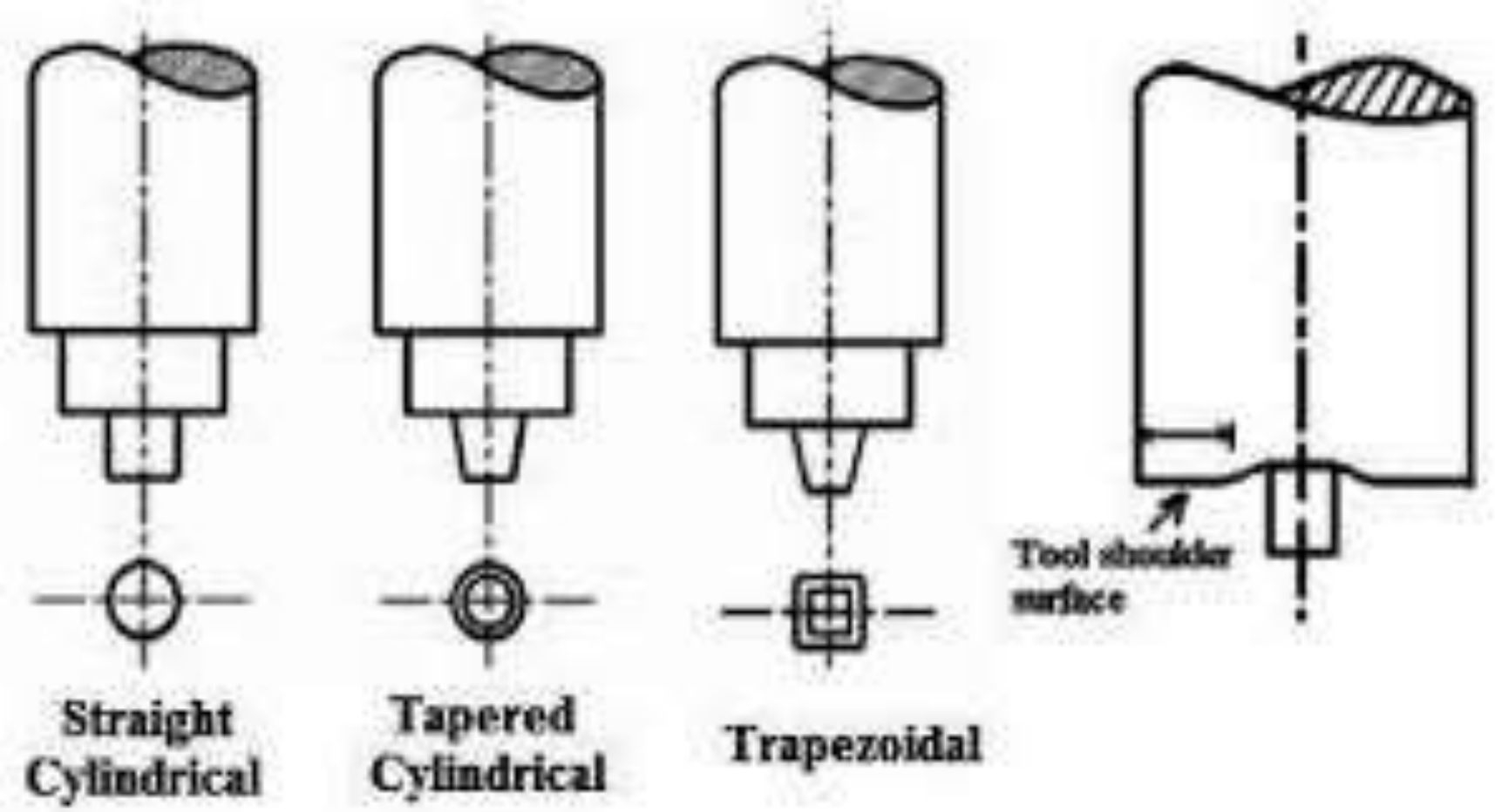
- **while FSW produces HAZs.**

FRICTION STIR TOOL



platinum alloys, iridium alloys and ceramics


Pion / *Pin*
Epaulement
/ *Shoulder*
Outil FSW
/ *FSW tool*

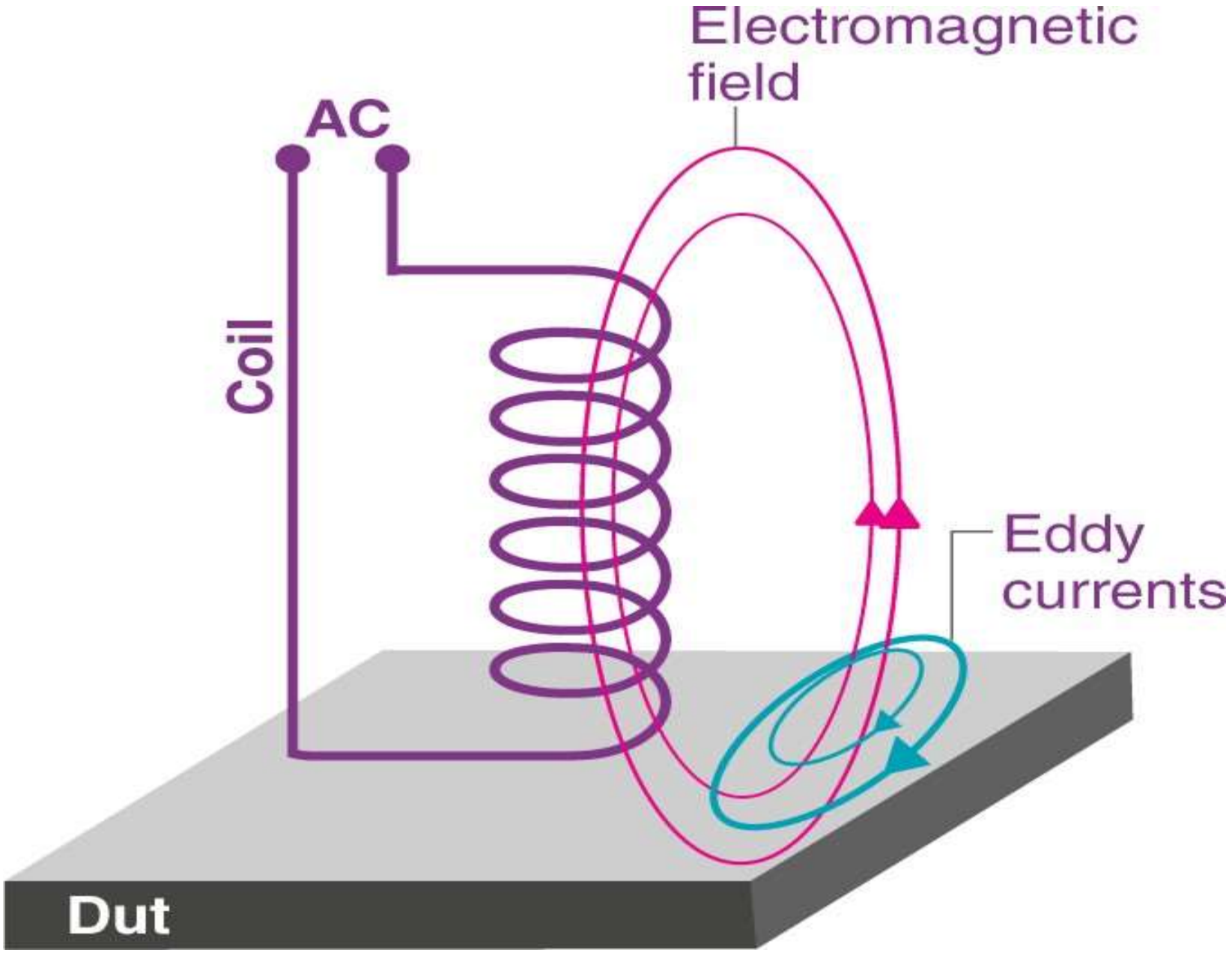

Straight
Cylindrical
Tapered
Cylindrical
Trapezoidal
Tool shoulder
surface

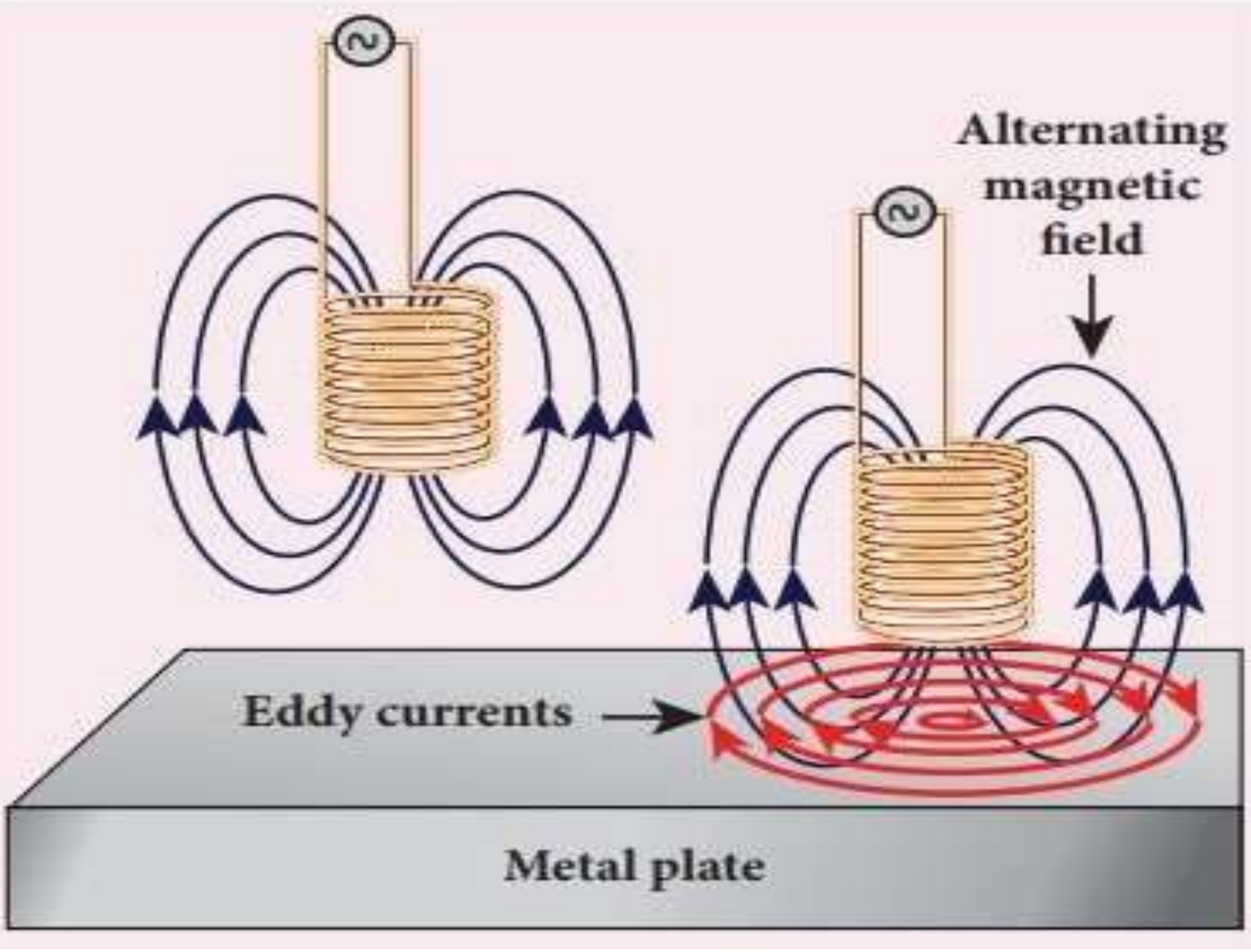
INDUCTION WELDING


Prestige
Prestige
CONTROL PANEL
PIC 16.0

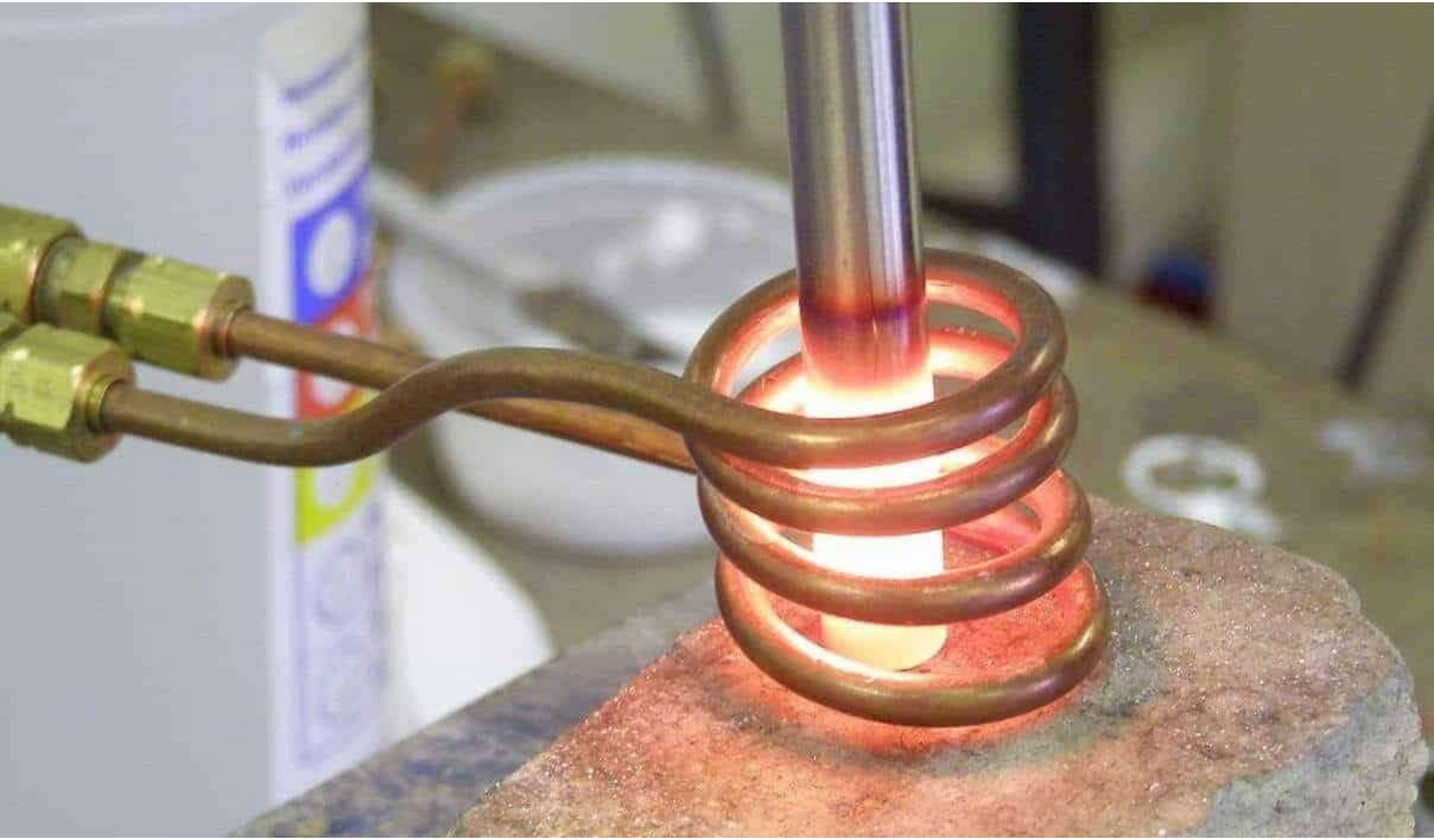
- **Induction heating is a type of electric heating in which currents induced in the material by electromagnetic action are used to heat it.**

- **It is a contactless electric heating method in which the material will be heated without making any direct contact with the supply.**


Electromagnetic
field
AC
Coil
Eddy
currents
Dut


Alternating magnetic field
Eddy currents
Metal plate

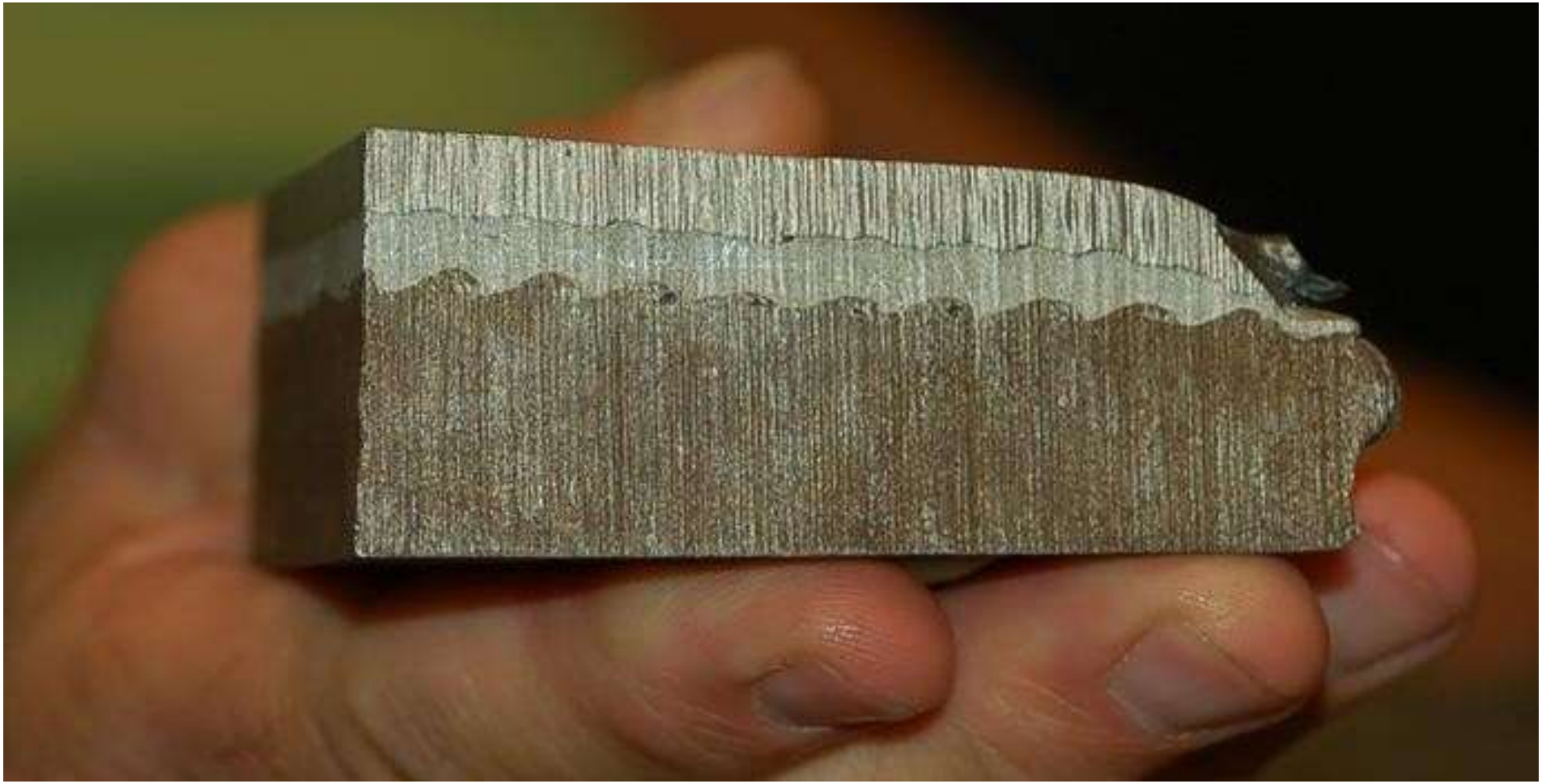
- **When induction welding takes place, the work pieces heat up to the melting temperature and the edges of the pieces are placed together**
- **Induction heating is used both domestic and commercial cooking, in several applications such as heat treating, soldering, preheating for welding, melting**

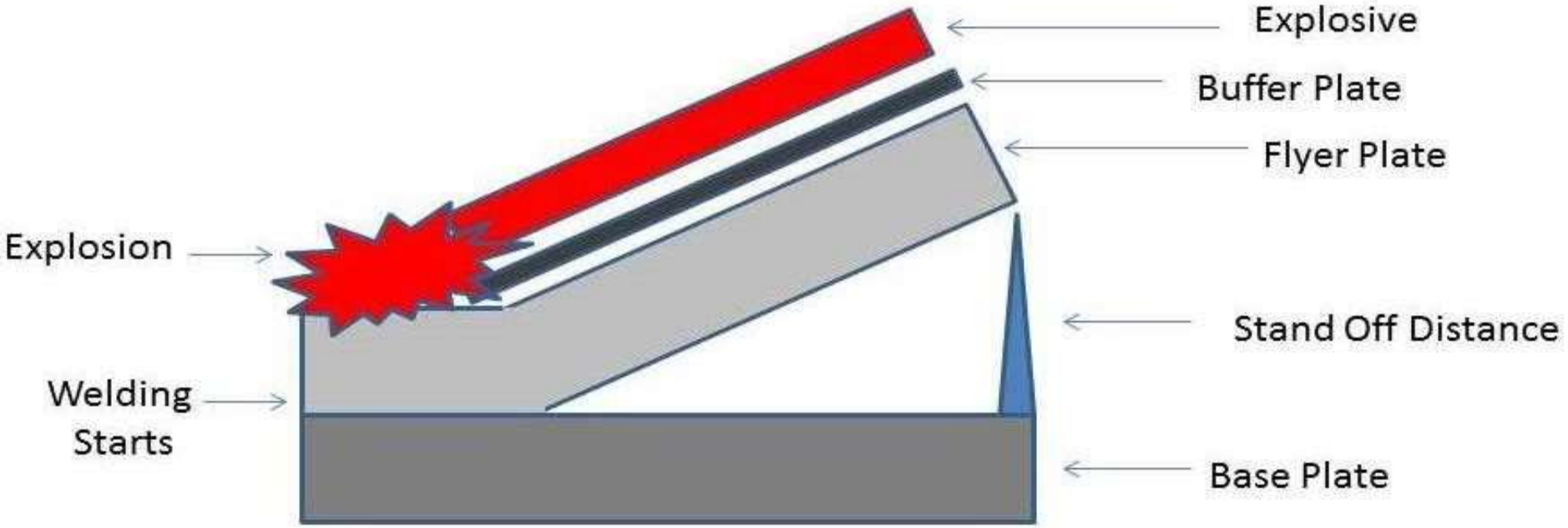


- **Induction heating is the phenomenon by which eddy currents formed in an electrically conductive material through Faraday's Law of Induction, heat the object.**
- **In the area where the eddy currents are flowing, the phenomenon of resistance will then generates heat.**
- **Increasing the strength of the magnetic field increases the heating effect.**


© Fives

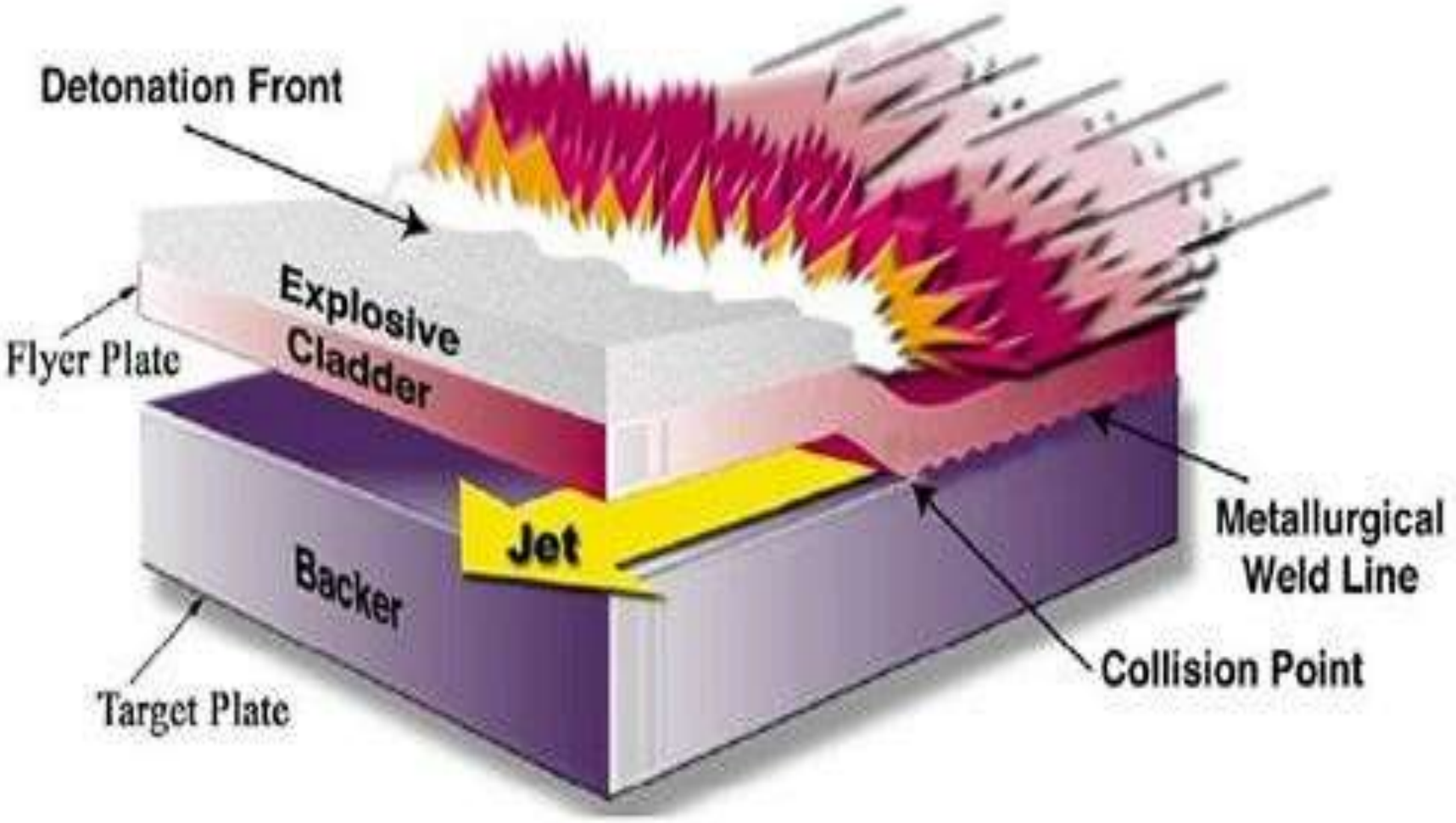
EXPLOSIVE WELDING





Explosion Welding

- **In explosive welding, a compression force created by detonation of explosives is used to join overlapping metal sheets.**
- **The joining parts are arranged toward each other at an angle of 1–15°, depending on the material**
- **The method is often used for a combination of materials that are difficult to join using other methods.**

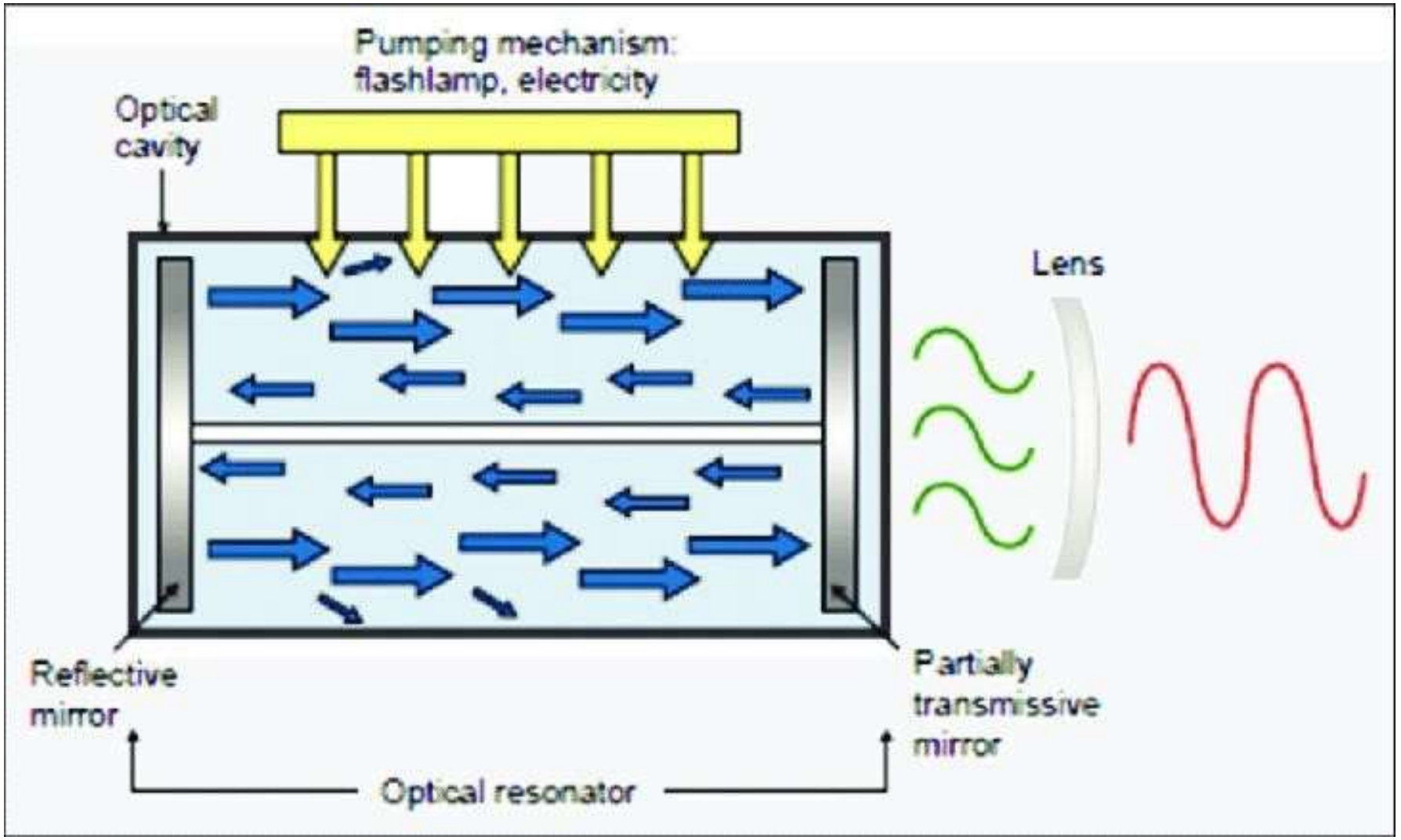

Detonation Front
Flyer Plate
Explosive
Cladder
Jet
Backer
Target Plate
Metallurgical
Weld Line
Collision Point

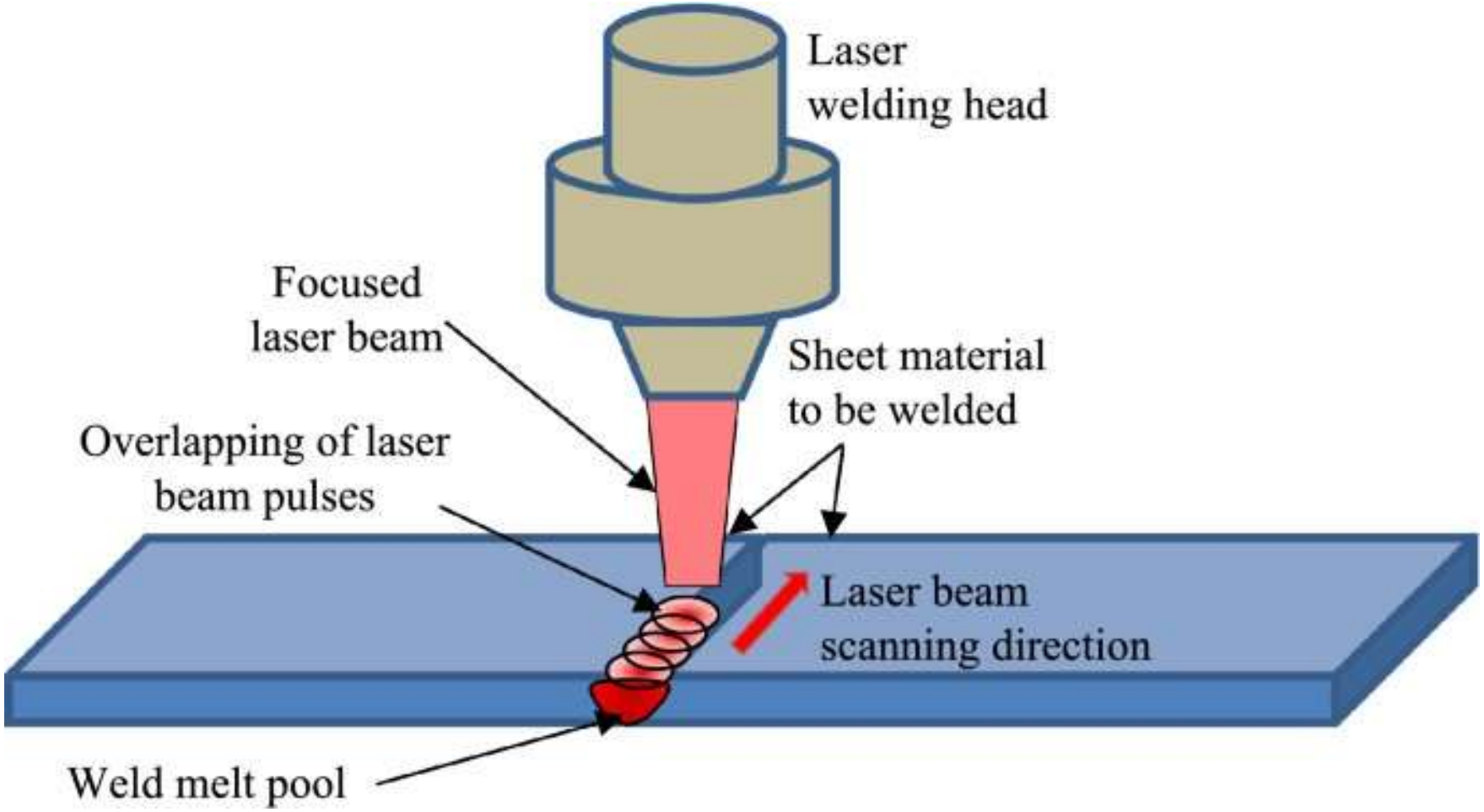
- **EXPLOSION WELDING (EXW), also known as explosive bonding, is accomplished by a high-velocity impact between two metals.**
- **The impact must have sufficient energy to cause the colliding metal surfaces to flow hydrodynamically when they intimately contact one another in order to form solid-state bonding.**

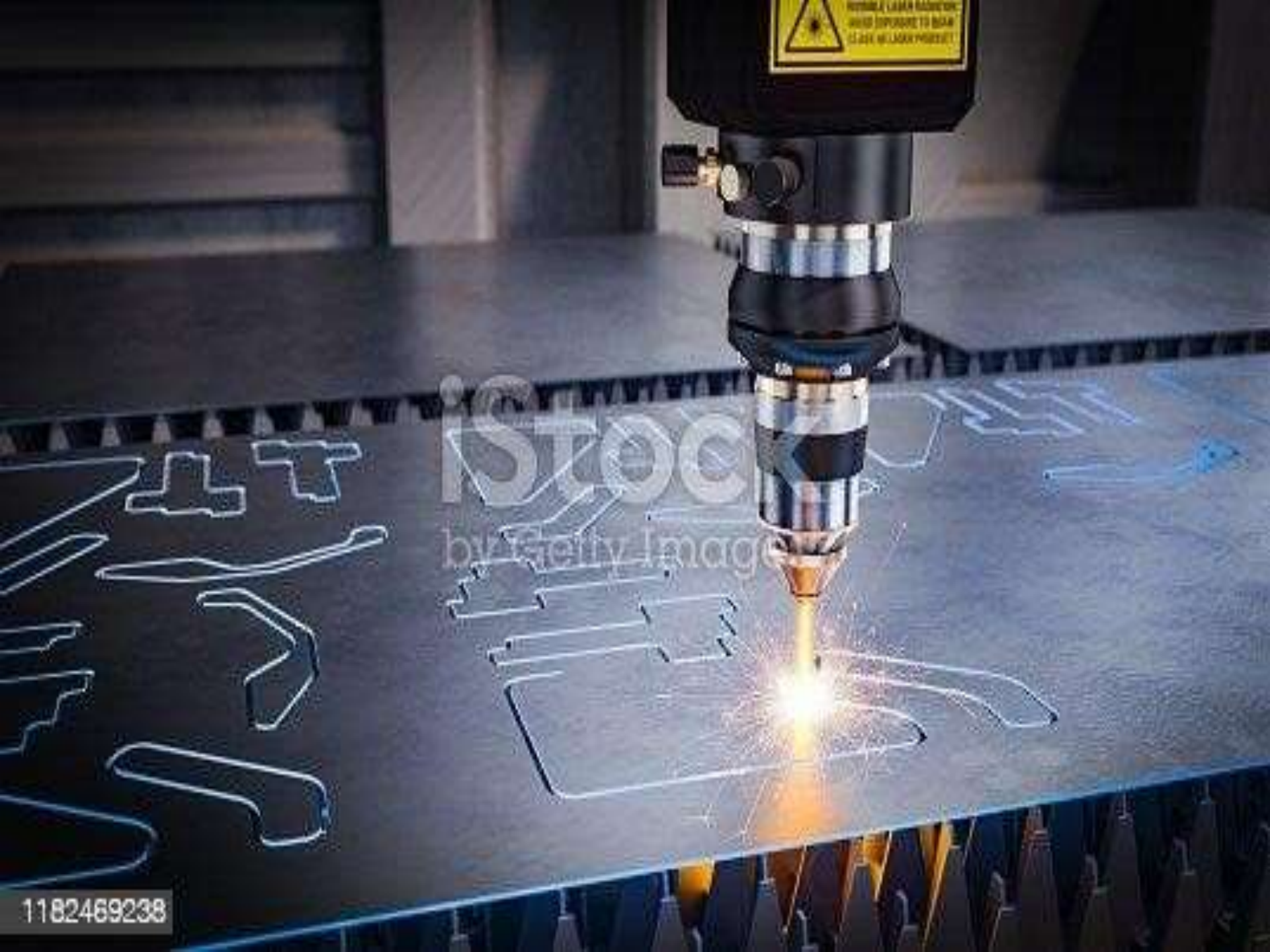
LASER WELDING

- **Laser beam welding is a fusion welding process in which two metal pieces are joined together by the use of laser.**
- **The laser beam provides a concentrated heat source, focused to the cavity between the two metal pieces to be joined.**

- **Laser is produced by the energy released by electrons moving from high-energy to low-energy orbits , followed by the collision with excited atoms**
- **Lasing gases combinations of helium, nitrogen, and CO_2.**
- **Lasing solids Ruby, diamond etc**


Pumping mechanism:
flashlamp, electricity
Optical
cavity
Lens
Reflective
mirror
Partially
transmissive
mirror
Optical resonator


Laser
welding head
Focused
laser beam
Sheet material
to be welded
Overlapping of laser
beam pulses
Laser beam
scanning direction
Weld melt pool


iStock
by Getty Images
1182469238

- **Soldering is a joining process used to join different types of metals together by melting solder.**

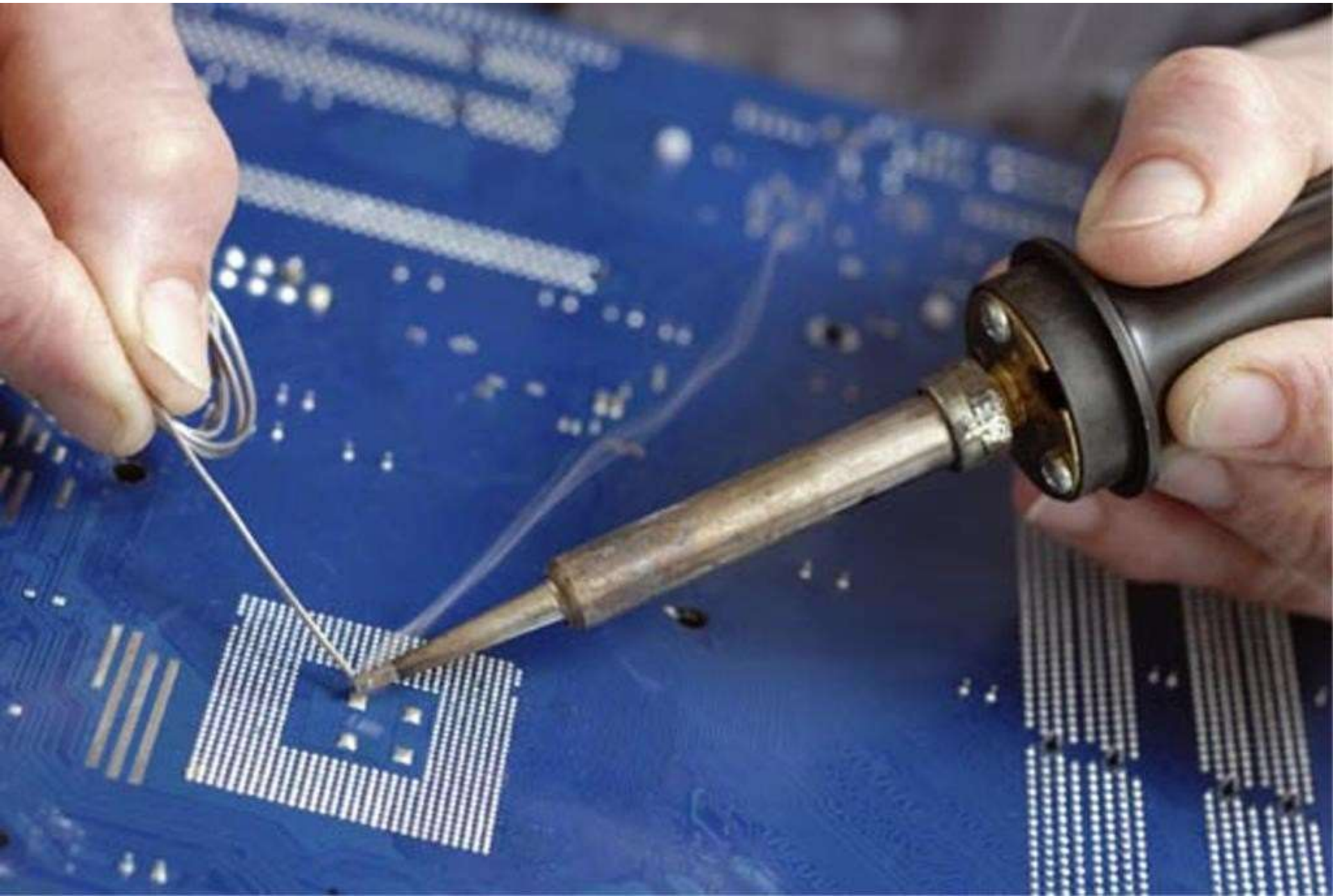
- **Solder is a metal alloy usually made of tin and lead which is melted using a hot iron.**

Step 1: Begin by making sure the tip is attached to the iron and screwed tightly in place.

Step 2: Turn on your soldering iron and let it heat up.

Step 3: Wipe the tip of the soldering iron on a damp wet sponge to clean it.

SOLDERING



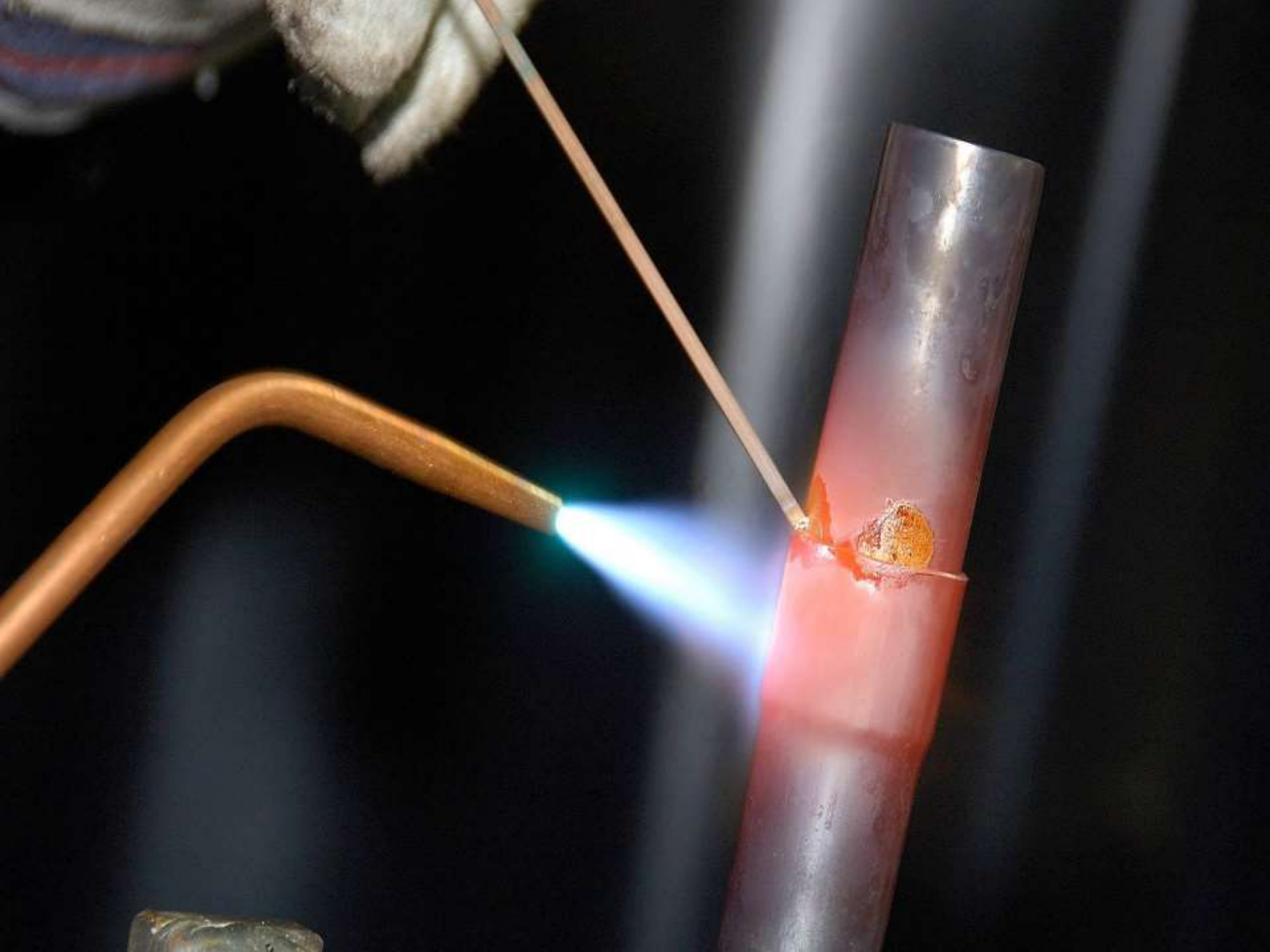

Weller
350°C
350

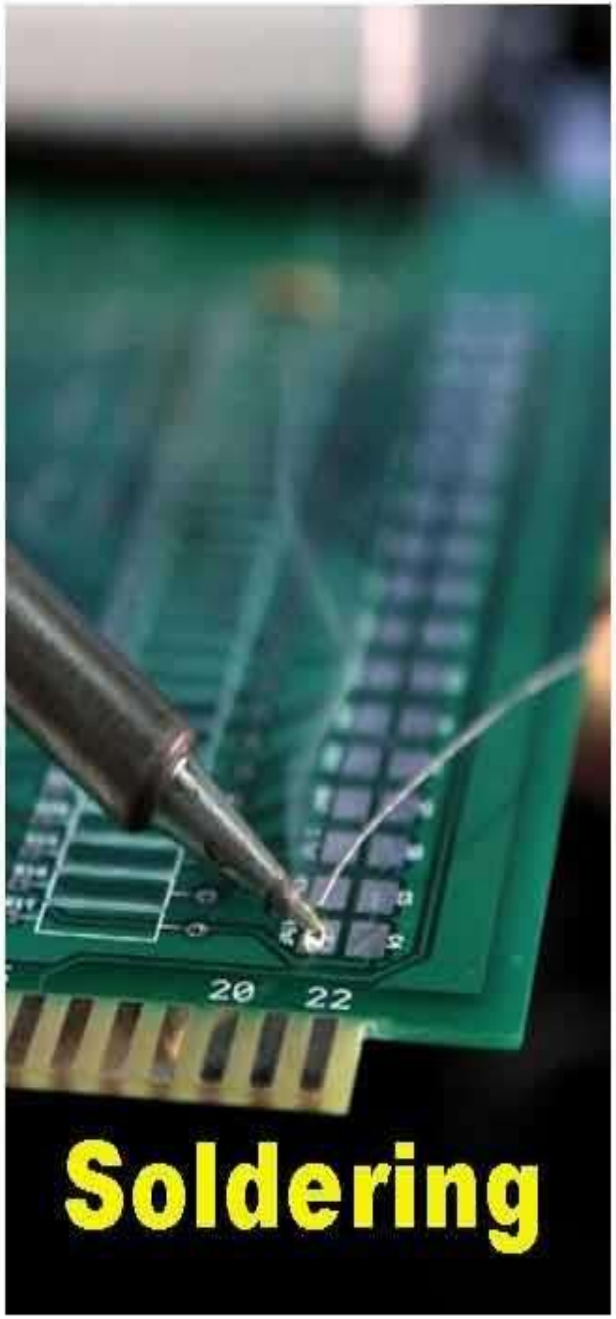
BRAZING

- **Brazing, process for joining two pieces of metal that involves the application of heat and the addition of a filler metal. This filler metal has a lower melting point than the metals to be joined.**

- **The only difference between soldering and brazing is the temperature at which each process takes place.**

- **Soldering takes place at a temperature below 450°C, and brazing occurs at a temperature above 450°C.**




Soldering


Brazing

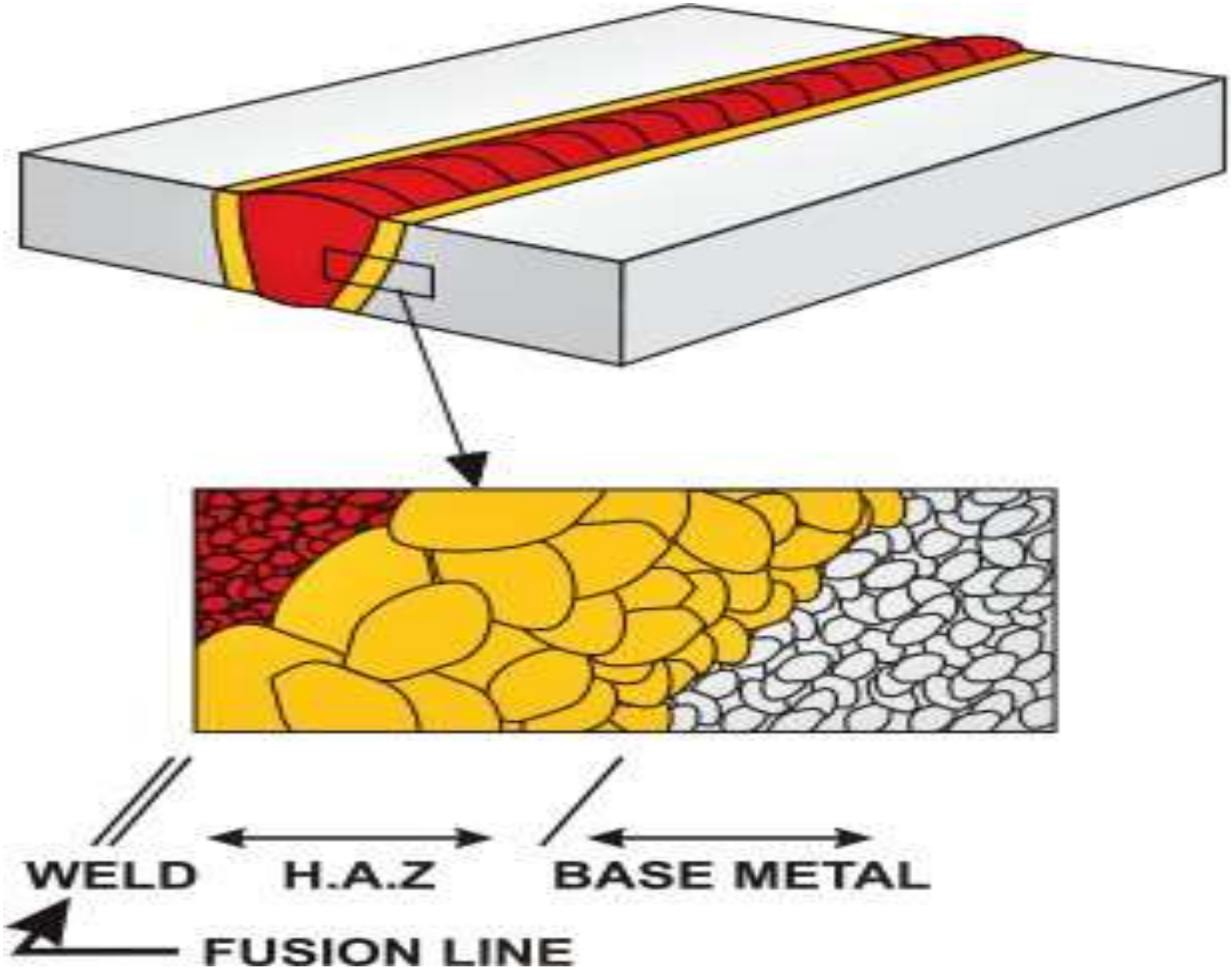

Welding

- **Compared with welding, brazing requires relatively low temperatures and can join dissimilar metals.**

- **Brazing filler materials come in a wide range of compositions, shapes, and sizes to suit most applications.**

HEAT AFFECTED ZONE

The heat affected zone (HAZ) is a non-melted area of metal that has undergone changes in material properties as a result of being exposed to high temperatures.

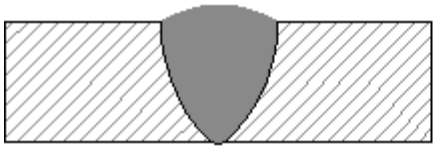

WELD
H.A.Z
BASE METAL
FUSION LINE

Types of Welding Defects.

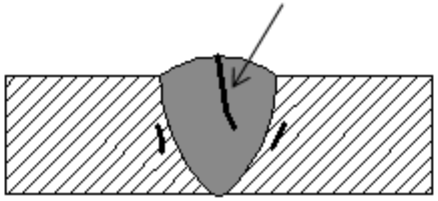
- Slag Inclusions.
- Porosity.
- Undercut.
- Weld Crack.
- Incomplete Fusion.
- Incomplete flow.
- Spatter.

Different Welding Defects

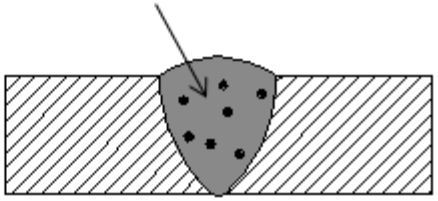
Ideal Weld



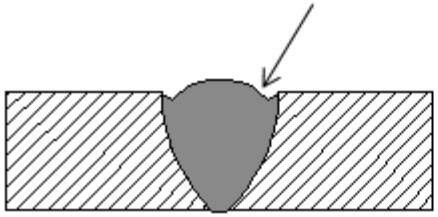
Cracks

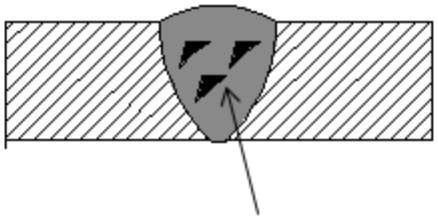


Porosity



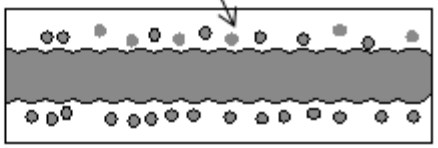
Undercut



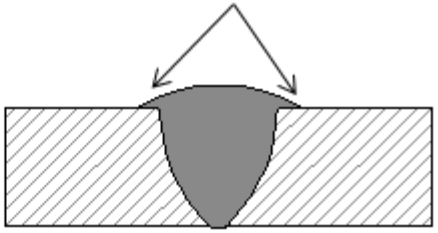


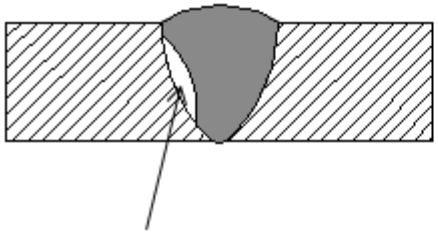
Slag Inclusion

Spatter

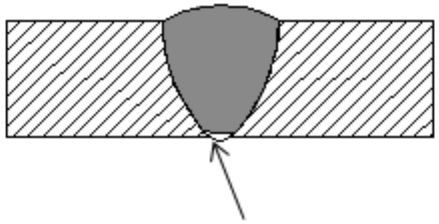


Overlap





Incomplete Fusion



Incomplete Penetration

Welding defects Causes:

- **Too high weld current.**
- **Too fast weld speed.**
- **The use of an incorrect torch angle, which will direct more heat to free edges.**
- **The electrode is too large.**
- **Incorrect usage of gas shielding.**
- **Incorrect filler metal.**
- **Poor weld technique.**

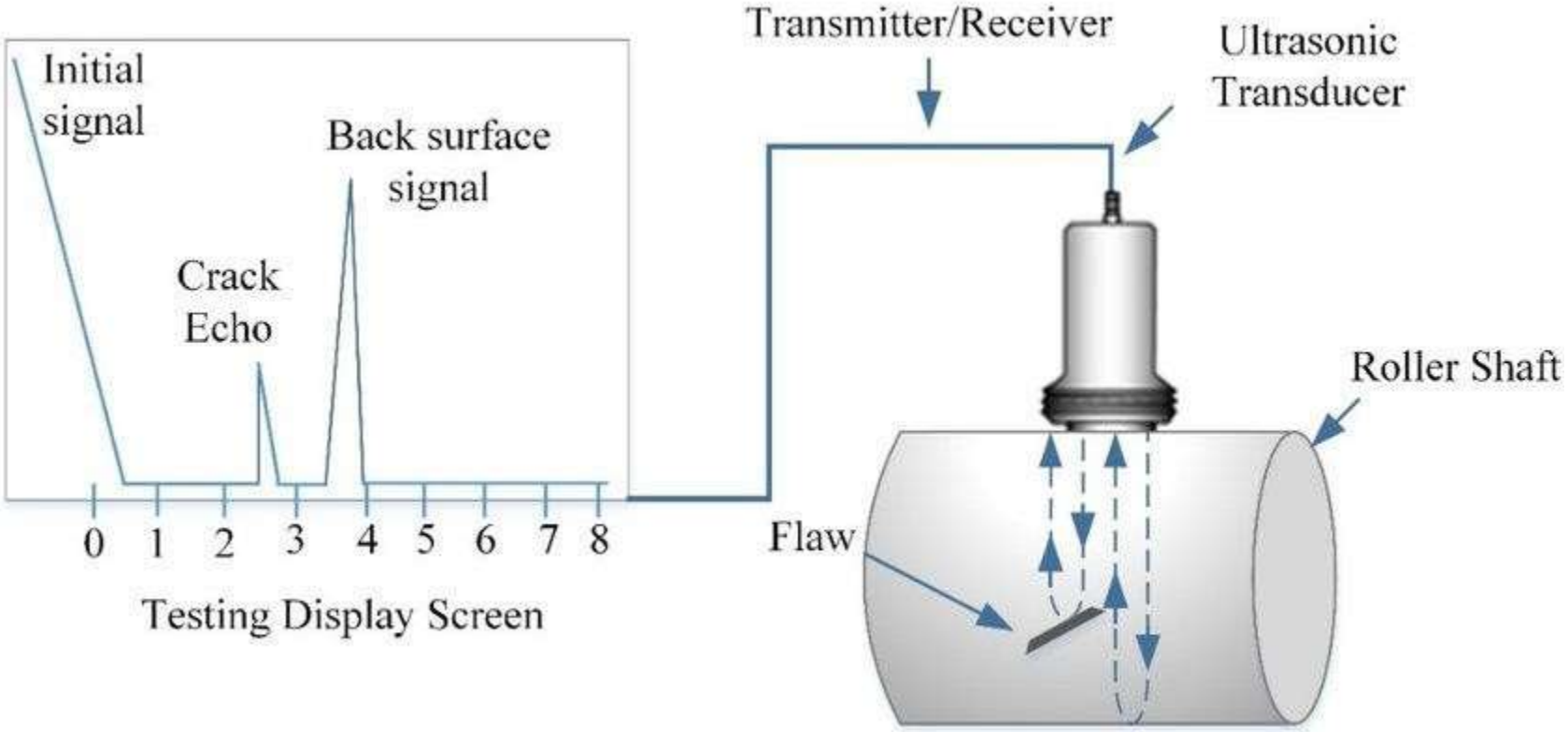
Destructive testing is conducted by damaging the specimen that is being tested. In contrast, during non-destructive testing (NDT), the tested item does not suffer any physical damage and can be used in active operation after the testing.

NON DESTRIUCTIVE TESTS

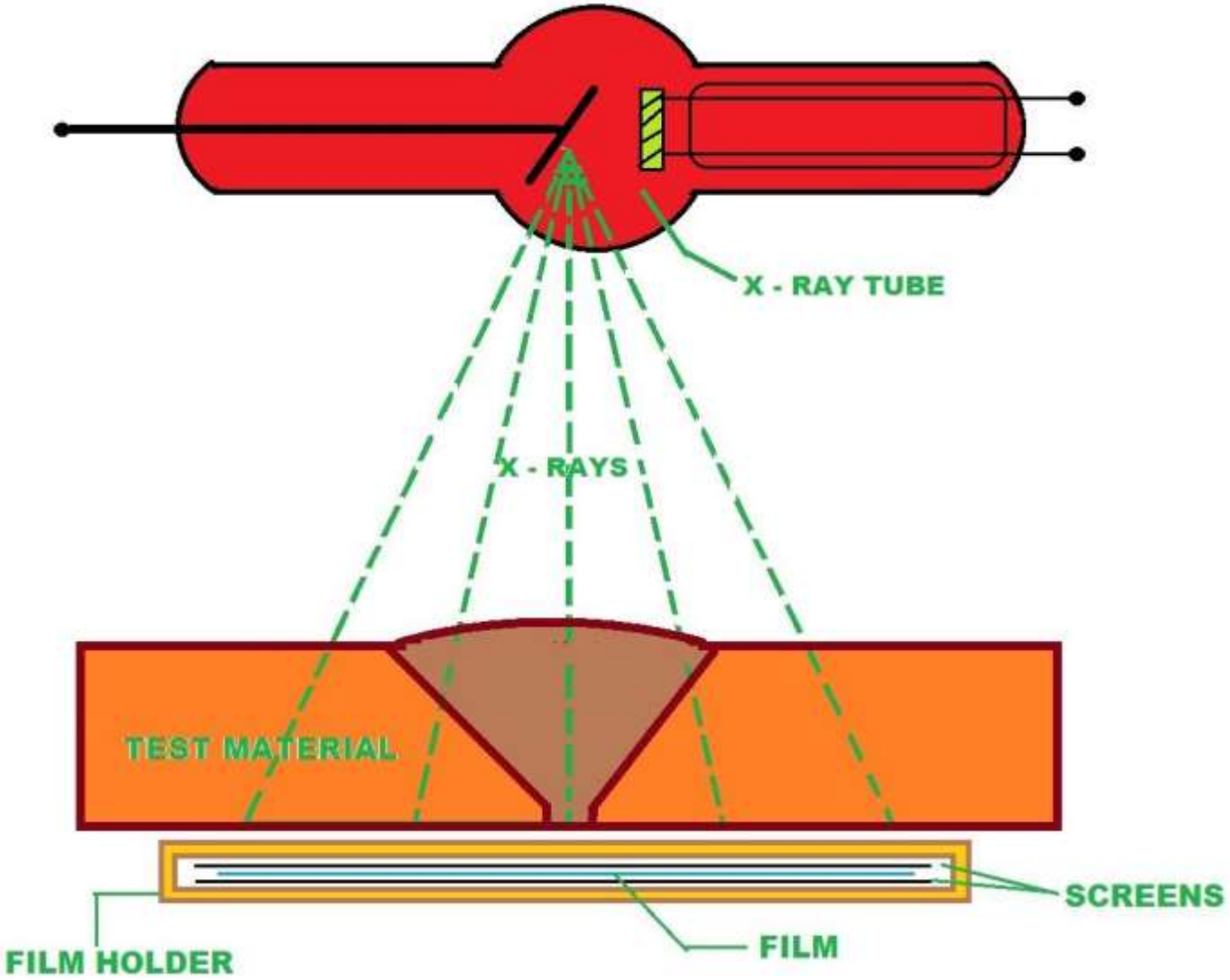
- Visual NDT (VT)
- Ultrasonic NDT (UT)
- Radiography NDT (RT)
- Eddy Current NDT (ET)
- Magnetic Particle NDT (MT)
- Acoustic Emission NDT (AE)
- Dye Penetrant NDT (PT)
- Leak Testing (LT)

Ultrasonic testing is done in materials to determine whether there are flaws or defects present in a material, and also to determine the thickness of a material. Ultrasonic testing methods use sound waves to find defects and measure thickness.

Radiographic Testing (RT) is a non-destructive testing (NDT) method which uses either x-rays or gamma rays to examine the internal structure of manufactured components identifying any flaws or defects. In Radiography Testing the test-part is placed between the radiation source and film

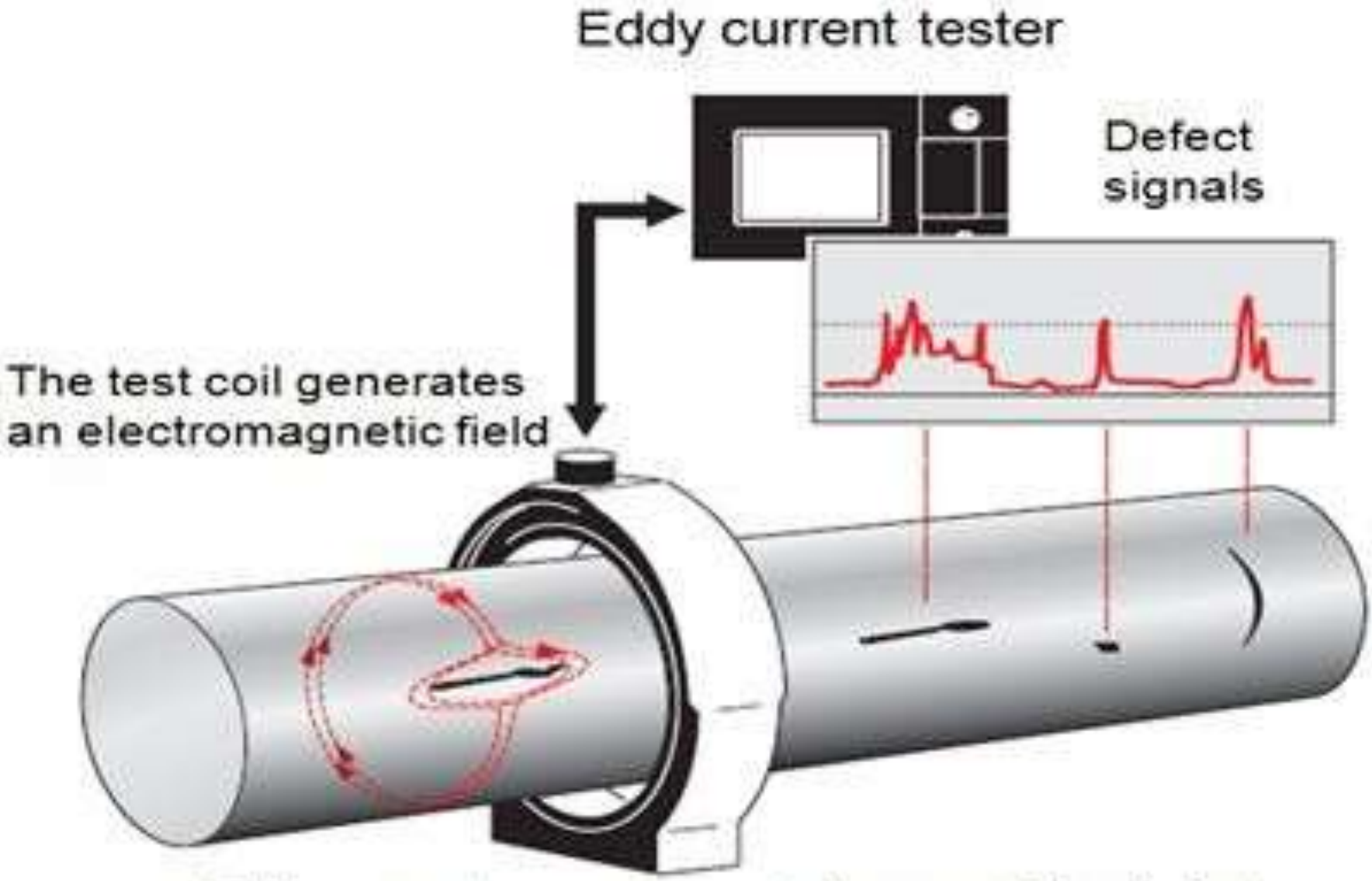

Initial signal
Back surface signal
Crack Echo
0 1 2 3 4 5 6 7 8
Testing Display Screen
Transmitter/Receiver
Ultrasonic Transducer
Roller Shaft
Flaw

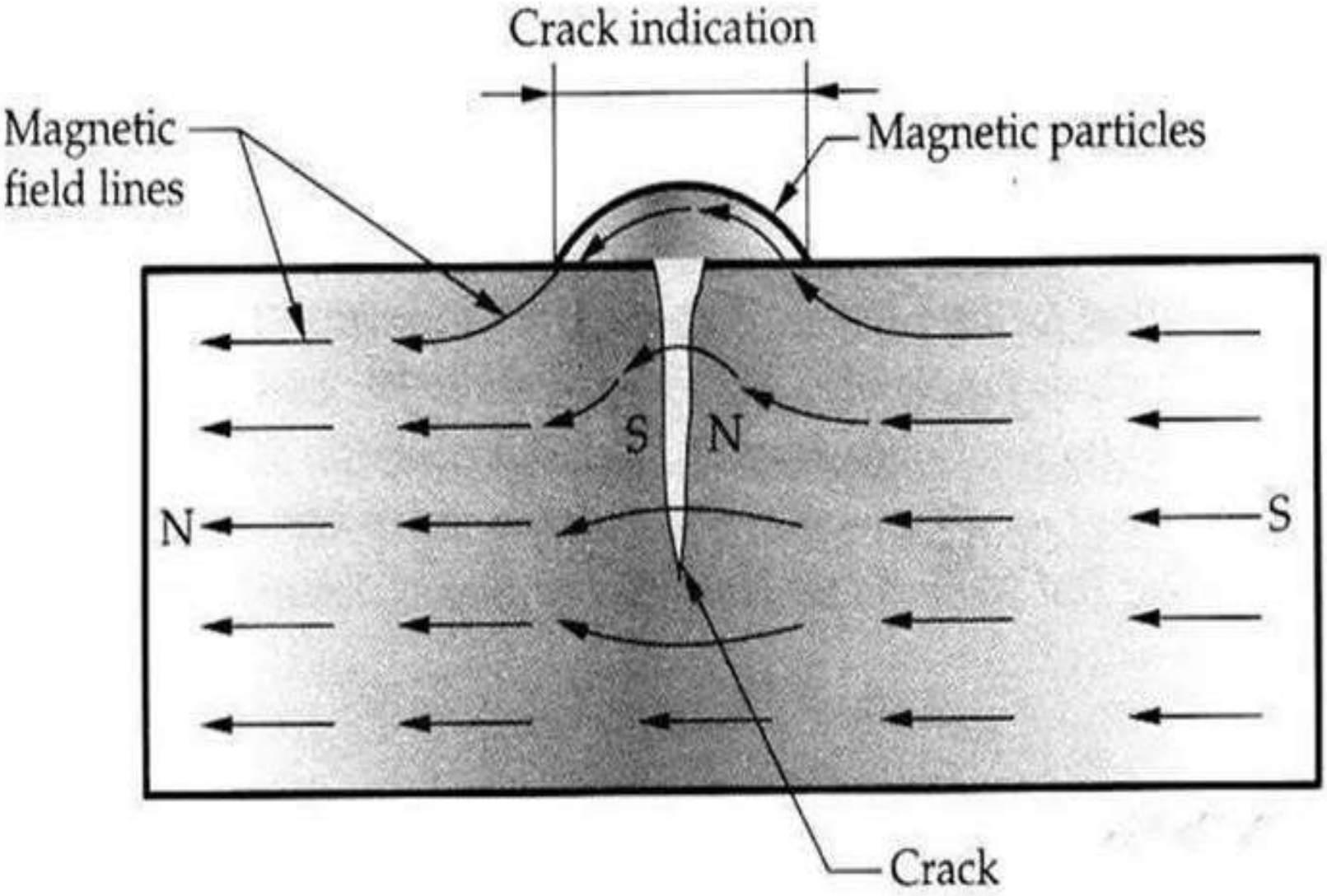
RADIOGRAPHY USING X-RAY



Eddy Current Testing (ET) is a versatile NDT method that can be used to detect (near) surface defects in conductive materials without removing the coating. An electromagnetic inductor is used to generate a magnetic field.

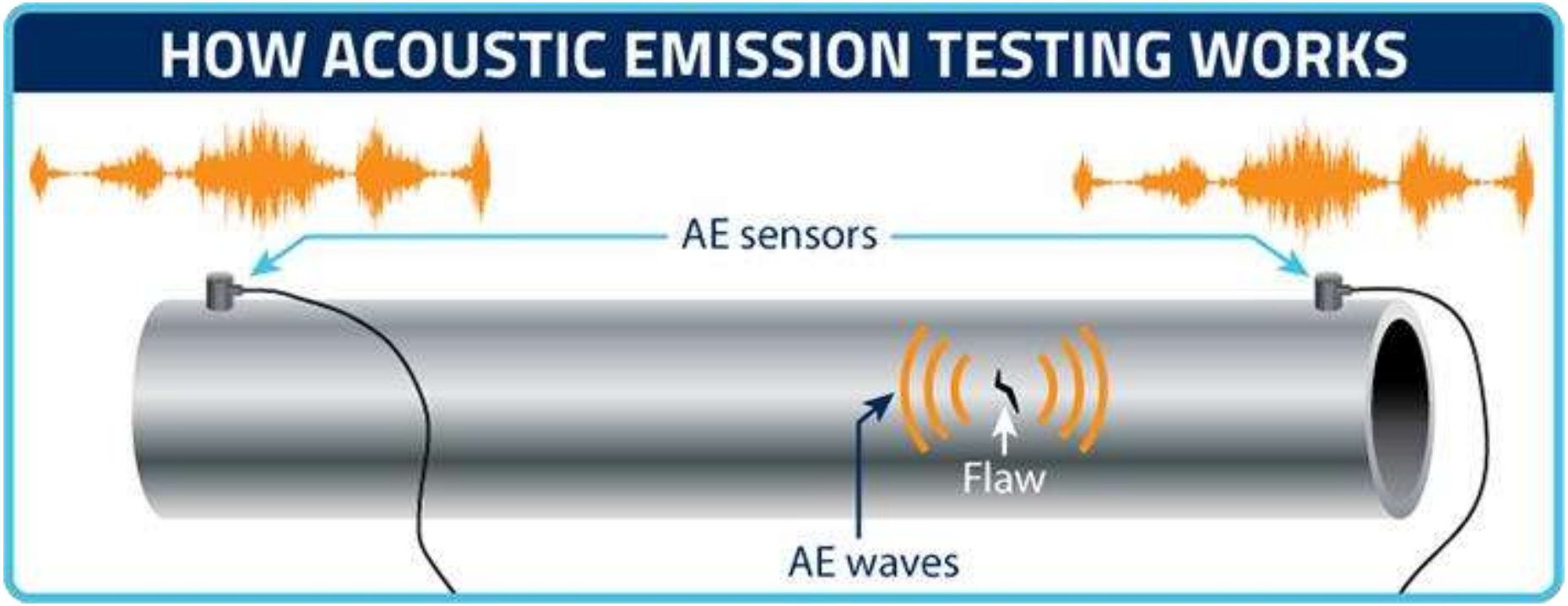
Magnetic particle testing, or MT, is a very sensitive, nondestructive testing method used on rigid materials like iron, cobalt, nickel and their alloys. It's one of the fastest, most cost-efficient ways to ensure that critical elements like pipes or pipe welds are safe and ready to be used


Eddy current tester
Defect signals
The test coil generates an electromagnetic field
Eddy currents are generated around the defect and are detected by the test coil


Crack indication
Magnetic field lines
Magnetic particles
S
N
N
S
Crack

Acoustic emission (AE) testing is a non-destructive testing (NDT) technique that detects and monitors the release of ultrasonic stress waves from localised sources when a material deforms under stress.

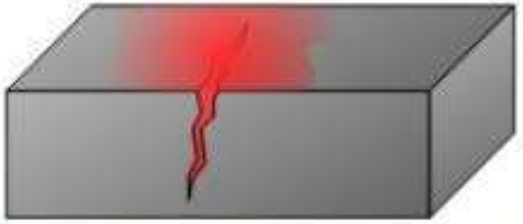
Dye Penetrant Inspection (DPI) is widely used to detect surface breaking flaws. This non-destructive testing technique, also known as liquid penetrant inspection (LPI), is a cost-effective method used to locate surface breaking flaws such as cracks, porosity, laps, seams and other surface discontinuities.


HOW ACOUSTIC EMISSION TESTING WORKS
AE sensors
Flaw
AE waves

Dye Penetrant Testing

1) contaminated workpiece

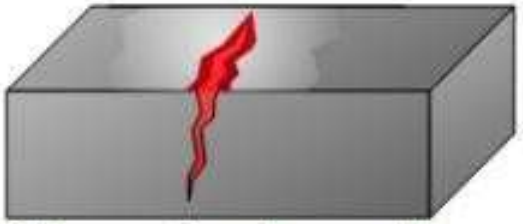
2) cleaning the workpiece



3) applying the flaw detection ink

4) rinsing the workpiece

5) applying the dye developer



6) inspecting the crack

Leak testing is a procedure that inspectors use to determine whether an object or system is functioning within a specific leak limit. Leaks occur when there is a defect—a hole, crack, or some other kind of flaw—in an object, allowing whatever the liquid or gas it is holding to flow out.