***Subject:* Advance Welding (PE-ME702H)**
***Name*: Soumyabrata Maity**
***Stream*: Mechanical Engineering**
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***Roll NO:* 16300721026**

5. **<u>Slag</u>:**

Slag is a byproduct of metal smelting, and hundreds of tons of it are produced every year all over the world in the process of refining metals and making alloys. Like other industrial byproducts, slag actually has many uses, and rarely goes to waste. It appears in concrete, aggregate road materials, as ballast, and is sometimes used as a component of phosphate fertilizer. In appearance, slag looks like a loose collection of aggregate, with lumps of varying sizes. It is also sometimes referred to as cinder, in a reference to its sometimes dark and crumbly appearance.

This substance is produced during the smelting process in several ways. Firstly, slag represents undesired impurities in the metals, which float to the top during the smelting process. Secondly, metals start to oxidize as they are smelted, and slag forms a protective crust of oxides on the top of the metal being smelted, protecting the liquid metal underneath. When the metal is smelted to satisfaction, the slag is skimmed from the top and disposed of in a slag heap to age. Aging material is an important part of the process, as it needs to be exposed to the weather and allowed to break down slightly before it can be used.

Aluminum is a common component of slag, along with silicon and magnesium. Common components of slag include the oxides of silicon, aluminum, and magnesium, as well as sulfur, which is always present. It also contains phosphorous, calcium, ash, remnants of flux materials such as limestone, and remainders of chemical reactions between the metal and the furnace lining. Other compounds found in this material depend on the type of smelting. Non-ferrous smelting, used to refine copper, lead, and similar metals, produces highly ferrous slag, as iron is an undesired element. Ferrous smelting, such as that used to produce steel, creates non ferrous slag, as all the iron is used in the smelting process.

<u>Advantages of Steel Slag</u>

The main advantage of steel slag is its cost-effectiveness. Because it’s produced as a by-product of metal melting, it’s generally much cheaper than traditional aggregates or materials like asphalt or concrete. Additionally, steel slag has great compressive strength and can be used as an alternative to gravel or other materials in roadbeds and foundations. Furthermore, its heat resistance makes it useful for applications where temperatures may get hot enough to damage more traditional materials like asphalt.

Steel slag also has several environmental advantages over traditional materials. For example, it reduces air pollution because its production doesn't require burning fossil fuels like oil or natural gas that produce harmful emissions when burned. Additionally, because it doesn't require mining to obtain raw materials (like sand and gravel do), there are fewer environmental impacts associated with steel slag production than with traditional construction materials. Finally, steel slag is resistant to erosion so roads built with this material can last longer than roads made with other types of aggregate or asphalt.

Disadvantages of Steel Slag

The primary disadvantage of using steel slag is that it's not suitable for all applications. For example, while the compressive strength makes it useful in roadbeds, its lack of tensile strength makes it unsuitable for use in structures that need to bear weight or withstand movement (like bridges). Additionally, some people may find its look unappealing and prefer more aesthetically pleasing alternatives like asphalt or concrete. Finally, while heat resistance is an advantage in many situations, high temperatures can still cause steel slag to buckle under pressure, so caution should be taken when considering this material for use in such scenarios

4. **Visual inspection:-**Visual inspection is a technique for detecting defects using the. naked eye to ensure equipment is working properly or that manufactured products are being made to specification. This can include visual inspections done in person or remotely using digital images.

   Radiography:-Radiography is an imaging technique using X-rays, gamma rays, or similar ionizing radiation and non-ionizing radiation to view the internal form of an object. Applications of radiography include medical radiography ("diagnostic" and "therapeutic") and industrial radiography. Similar techniques are used in airport security (where "body scanners" generally use backscatter X-ray). To create an image in conventional radiography, a beam of X-rays is produced by an X-ray generator and is projected toward the object. A certain amount of the X-rays or other radiation is absorbed by the object, dependent on the object's density and structural composition. The X-rays that pass through the object are captured behind the object by a detector (either photographic film or a digital detector). The generation of flat two dimensional images by this technique is called projectional radiography. In computed tomography (CT scanning) an X-ray source and its associated detectors rotate around the subject which itself moves through the conical X-ray beam produced. Any given point within the subject is crossed from many directions by many different beams at different times. Information regarding attenuation of these beams is collated and subjected to computation to generate two dimensional images in three planes (axial, coronal, and sagittal) which can be further processed to produce a three dimensional image

   Dye penetrant inspection:-Dye penetrant inspection (DP), also called liquid penetrate inspection (LPI) or penetrant testing (PT), is a widely applied and low-cost inspection method used to check surface-breaking defects in all non-porous materials (metals, plastics, or ceramics). The penetrant may be applied to all non-ferrous materials and ferrous materials, although for ferrous components magnetic-particle inspection is often used instead for its subsurface detection capability. LPI is used to detect casting, forging and welding surface defects such as hairline cracks, surface porosity, leaks in new products, and fatigue cracks on in-service components.

USW:-

Ultrasonic welding is a welding technique that uses mechanical vibrations above the audible range to generate frictional heat at the plastic joint area. The process is accomplished by converting high-frequency electrical energy into high mechanical motion.The vibrations generate heat at the joint interface of the parts being welded, resulting in melting of the thermoplastic materials and weld formation after cooling.Ultrasonic welding is used to join or reform materials through the use of heat generated from high-frequency mechanical motion.

Eddy current testing:- Eddy current testing is a non-destructive method used to check the condition of tubes in the condenser and evaporator sections of a chiller. An electronic probe is inserted in each tube at the end of a tube bundle and pushed through the entire length of the tube. The information fed back from the probe reveals abnormal tube wear or tube defects. Entech Sales & Service, LLC uses technologically advanced instrumentation for obtaining Air and Water readings to ensure state-of-the-art performance when testing and balancing buildings environmental systems. Eddy current testing is a no-contact method for the inspection of metallic parts. A test coil that is energized with alternating current is placed close to the test surface, which generates an alternating magnetic field that produces eddy currents in the test piece. The main areas where eddy current testing is used include crack and corrosion detection, non-conductive coating thickness measurement, material identification, and heat treatment condition.

3. **Resistance welding:-** Resistance welding is the joining of metals by applying pressure and passing current for a length of time through the metal area which is to be joined. The key advantage of resistance welding is that no other materials are needed to create the bond, which makes this process extremely cost effective.

   There are several different forms of resistance welding (e.g. spot and seam, projection, flash, and upset welding) which differ primarily by the types and shapes of weld electrodes that are used to apply the pressure and conduct the current. The electrodes, typically manufactured from copper based alloys due to superior conductive properties, are cooled by water flowing through cavities inside the electrode and the other conductive tooling of the resistance welding machine.

   Resistance welding machines are designed and built for a wide range of automotive, aerospace and industrial applications. Through automation, the action of these machines is highly controlled and repeatable allowing manufacturers to staff production readily.

   Types of Resistance Welding Applications:

Spot Welding and Seam Welding

Resistance Spot Welding, like all Resistance Welding Processes, creates welds using heat generated by resistance to the flow of welding current between the faying surfaces, as well as force to push the workpieces together, applied over a defined period of time. Resistance Spot Welding uses the face geometries of the welding electrodes themselves to focus the welding current at the desired weld location, as well as to apply force to the workpieces. Once sufficient resistance is generated, the materials set down and combine, and a weld nugget is formed.

Resistance Seam Welding is a subset of Resistance Spot Welding using wheel-shaped electrodes to deliver force and welding current to the parts. The difference is that the workpiece rolls between the wheel-shaped electrodes while weld current is applied. Depending on the particular weld current and weld time settings, the welds created may be overlapping, forming a complete welded seam, or may simply be individual spot welds at defined intervals.

Projection Welding

Like other Resistance Welding Processes, Projection Welding uses heat generated by resistance to the flow of welding current, as well as force to push the workpieces together, applied over a defined period of time. Projection Welding localizes the welds at predetermined points by using projections, embossments or intersections, all of which focus heat generation at the point of contact. Once the weld current generates sufficient resistance at the point of contact, the projections collapse, forming the weld nugget. Solid Projections are often used when welding fasteners to parts. Embossments are often used when joining sheet or plate material. An example of Projection Welding using material Intersections is cross-wire welding. In this case the intersection of the wires themselves localizes heat generation, and therefore resistance. The wires set-down into one another, forming a weld nugget in the process.

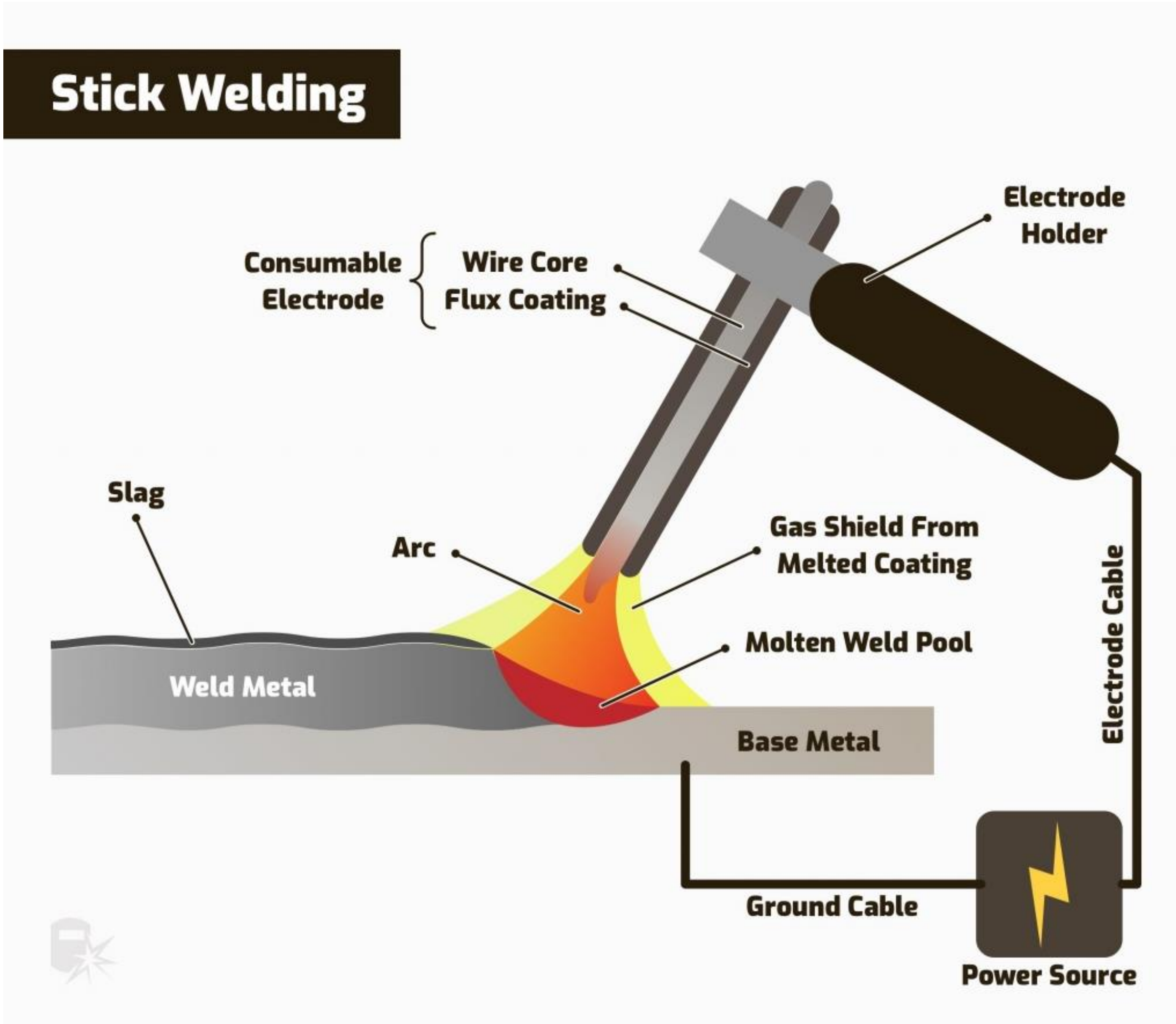
Flash Welding

Like other Resistance Welding Processes, Flash Welding uses heat generated by resistance to the flow of welding current, as well as force to push the workpieces together, applied over a defined period of time. Flash Welding is a Resistance Welding Process which generates resistance using flashing action. This action is created using very high current density at very small contact points between the workpieces. At a predetermined point after the flashing process has begun, force is applied to the workpiece, and they are moved together at a controlled rate. Rapid upset created by this force expels oxides and impurities from the weld.

Upset Welding

Like other Resistance Welding Processes, Upset Welding uses heat generated by resistance to the flow of welding current, as well as force to push the workpieces together, applied over a defined period of time. While similar to Flash Welding, in Upset Welding the workpieces are already in firm contact with one another, so no flashing occurs. Pressure is applied before the current is started, and is maintained until the process is complete.

2. **SMAW:-** Shielded Metal Arc Welding (SMAW), also known as stick welding, is a welding process that uses an electric current to form an arc at the end of a consumable electrode.



The SMAW welding machine produces a constant amperage in alternating current (AC) or direct current (DC).

This current travels from the machine, through the electrode, across the welding arc, and back to the machine through the work clamp.

When the electrode touches the workpiece in a scratching motion, the current will jump the gap between the electrode tip and the base metals. This jumping of the current forms a stable electric arc.

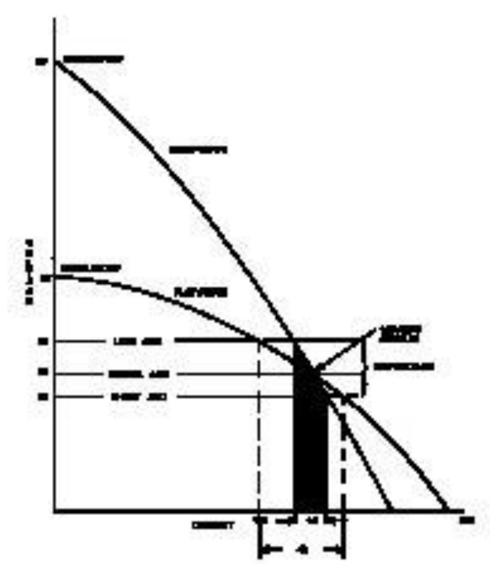
The heat from the arc melts the base metals along with the metal in the electrode. The electrode is then manipulated and moved along the joint to create a weld bead.

As the weld bead forms, the weld puddle consumes the metal in the electrode, adding it to the weld.

To protect the weld puddle from the atmosphere, SMAW electrodes have a flux coating, which burns and forms a protective shield. The flux coating also creates a layer of slag on the weld.

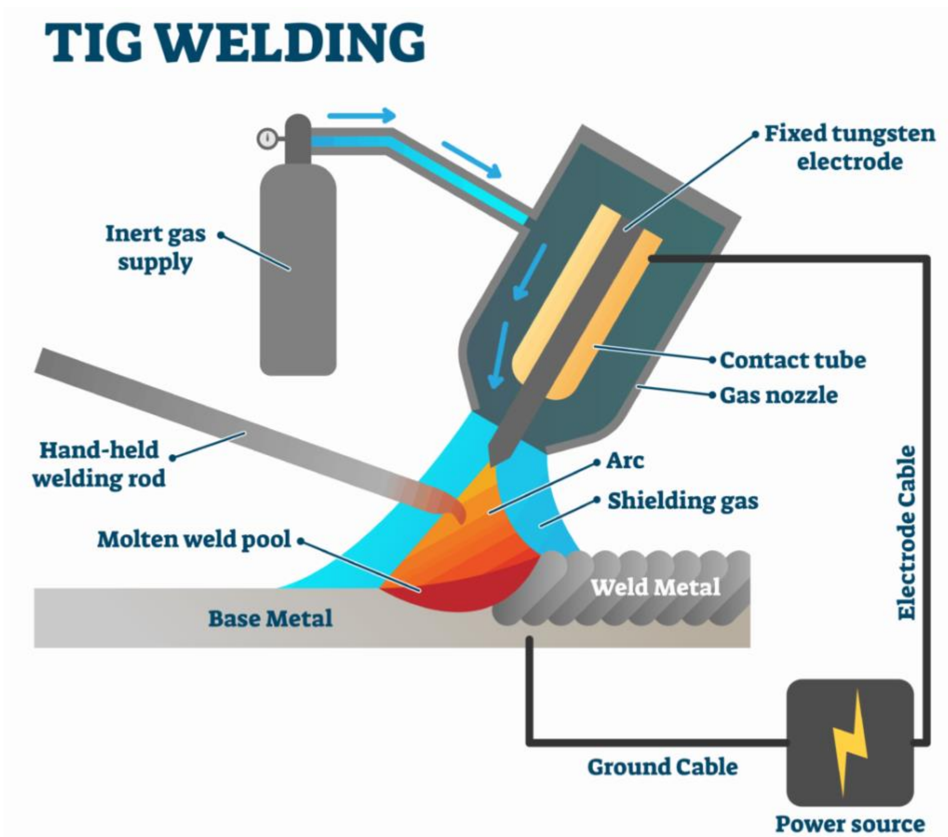
The SMAW electrode serves three purposes.
It conducts the electric current from the machine to the workpiece.
It provides the filler material for the weld.
A flux coating protects the weld from the atmosphere.
The center of the SMAW electrode is a bare metal rod selected to match the base metals of the weld joint. The numbers marked on the rod are a classification for the properties of the electrode.
This metal conducts the electric current from the welding machine to the workpiece.

Power-Sources or supplies generate and maintain the electric arc.Arc welding processes use specific equipment and consumables.The arc provides the localized heat needed to perform progressive welding.Power-Sources obtain their input from the power grid, and output their energy in usable and controlled form.Power Sources for Arc Welding transform the power from the grid to controlled values of voltage and of current suitable to the intended uses.This modification is required because the characteristics of the utility energy supplied are not suitable to establish the electric arc needed for welding.For most of welding purposes, welding voltage ranges from 20 to 80 volts (V) and current (with the exception of micro welding) from 30 to 1500 Amperes (A).Welding processes use direct current (dc), alternating current (ac) or pulsed current.Power-



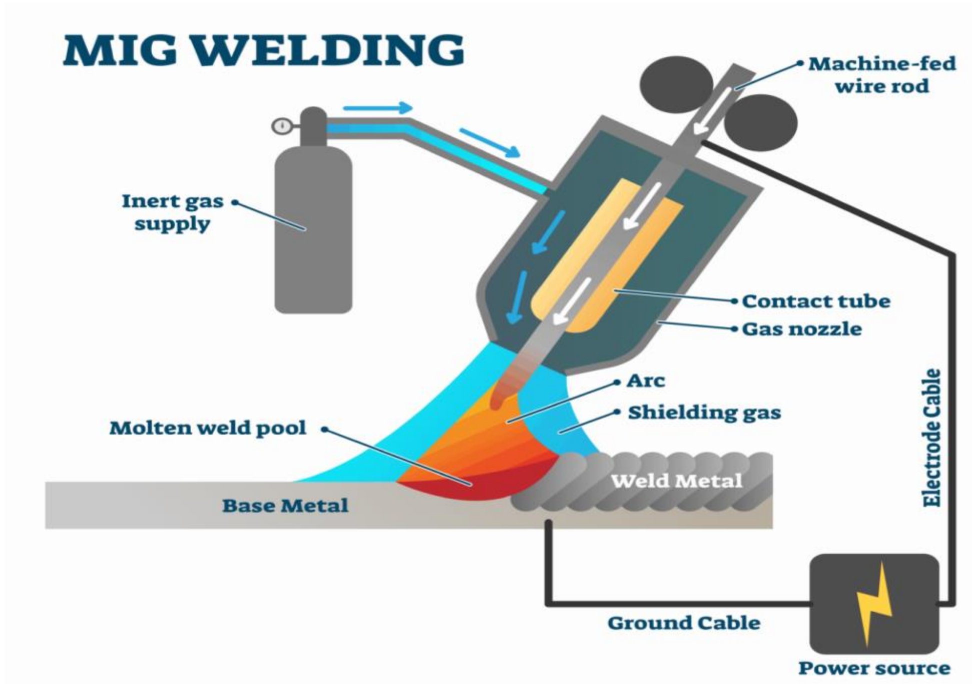
Sources are generally classified as constant current, constant voltage and waveform control or pulse welding.That qualifier (constant) must be understood as a useful simplification, not as an absolute value.The relationship is expressed graphically in a static volt-ampere characteristic diagram.More advanced Power-Sources with dedicated electronic devices can reach higher levels of control.Then the output is truly constant, generally supplied in pulses over a range of frequencies, as required for special applications.

1. **Tungsten inert gas**—welding is highly versatile, enabling industry professionals to join a wide range of small and thin materials. It uses a non-consumable tungsten electrode to heat the metal and can be used with or without a filler. Compared to MIG welding, it is much slower, often resulting in longer lead times and greater production costs. Additionally, welders require highly specialized training to ensure they achieve proper precision and accuracy. However, it also offers greater control during the welding operation and produces strong, precise, and aesthetically pleasing welds.



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.Compared to TIG welding, it is much faster, resulting in shorter lead times and lower production costs. Additionally, it is easier to learn and produces welds that require little to no cleaning and finishing.

However, its welds are not as precise, strong, or clean as those formed by TIG welding operations.



Three different polarities used in arc welding

<u>Direct Current Straight Polarity</u>—occurs when electrode is made negative and base plates are made positive. Thus electrons flow from electrode tip to base plates.

<u>Direct Current Reverse Polarity</u>—occurs when electrode is made positive and base plates are made negative. Thus electrons flow from base plates to electrode.

<u>Alternating Current Polarity</u>—if power source provides AC current then above two cases will occur one after another in every cycle. In one half of the cycle, electrode will be negative (so base plates will be positive) and in the next half, electrode will be positive (so base plate will be negative). Number of cycles per second depends on frequency of supply. For example, with a 60Hz supply, 60 cycles occur in every second.