WELDING TECHNOLOGY
AND
WELDING INSPECTION

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DEFINITION:

- PROCESS OF JOINING THE TWO METALS, EITHER SIMILAR OR DISSIMILAR TO THE BASE METAL.

- These processes use a welding power supply to create and maintain an electric arc between an electrode and the base material to melt metals at the welding point.

- The welding region is sometimes protected by some type of inert or semi-inert gas, known as a shielding gas, and filler material is sometimes used as well.

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WELDING HISTORY:
Welding was used in the construction of the Iron pillar in Delhi, India, erected about 310 and weighing 5.4 metric tons.
TYPES OF WELDING:

01. ARC WELDING
   a. Shielded metal arc welding (SMAW) or manual metal arc welding (MMAW)
   b. Gas metal arc welding (GMAW) or Metal inert gas welding (MIG).
   c. Flux cored arc welding (FCAW).
   d. Gas tungsten arc welding (GTAW) or Tungsten inert gas (TIG).
   e. Submerged arc welding (SAW).
   f. Carbon arc welding.
   g. Atomic hydrogen welding.
   h. Electro slag welding.
   i. Electro gas welding.
   J. Stud arc welding.

02. GAS WELDING.

03. RESISTANCE WELDING.

04. ENERGY BEAM.

05. SOLID STATE WELDING.

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SHIELDED METAL ARC WELDING (SMAW) OR MANUAL METAL ARC WELDING (MMAW):

- A manual arc welding process that use a consumable electrode coated in flux to lay the weld.
- An electric current either a.c or d.c from a welding power supply, is used to form an electric arc between the electrode and the metals to be joined.
- The preferred polarity depends upon the electrode being used.
- Negative charged electrode can increase the electrode melting rate and decrease the depth of weld.
- Reverse the polarity can increases the penetration.
- Typically the equipment used for SMAW consist of a step down transformer and a rectifier for converting the a.c into d.c.
- The welding transformer is used to reduce the voltage and current.
- Electric generator and alternator is used for constant power supply.
SMAW PROCESS:

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GAS METAL ARC WELDING (GMAW) OR METAL INERT GAS WELDING (MIG)

- IS A SEMI-AUTOMATIC or automatic process that uses a continuous wire feed as an electrode and an inert or semi-inert gas mixture to protect the weld from contamination.
- Since the electrode is continuous, welding speed is greater than SMAW.
- Equipment required is more complex and expensive than SMAW.
- Less versatile in nature.
- The process is applied to a wide variety of metals, both ferrous and non-ferrous.

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FLUX CORED ARC WELDING (FCAW):

- Uses wire consisting of a steel electrode surrounding a power fill material.
- The cored wire is more expensive than the solid standard wire and can generate fumes or slag.
- Higher welding speed can be obtained.
- It has greater metal penetration.
- Equipment is very similar to GMAW.
GAS TUNGSTAN ARC WELDING (GTAW) OR TUNGSTEN INERT GAS (TIG):

- Is a manual welding process that use a non consumable tungsten electrode, an inert or semi inert gas mixture, and a separate filler material.
- Especially useful for welding thin material.
- This method is characterized by a stable arc and high quality welds.
- It requires significant operator skills.
- It has relatively low welding speed.
- Not versatile in nature.
- Most useful in stainless steel and light metals.
- Application in bicycle, aircraft, naval etc.
- Plasma arc welding, also uses a tungsten electrode but uses plasma gas to make an arc.

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SUBMERGED ARC WELDING (SAW):

- Is a high productive welding method in which the arc struck beneath a covering layer of flux.
- The slag that forms on the weld generally comes off by itself, and combined with the use of continuous wire feed.
- The weld deposition rate is high.
- Working condition is much more improved and almost no smoke is produced.
- The process is commonly used in industry especially for large products and in the manufacture of welded pressure vessels.

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GAS WELDING:

- The most commonly gas welding process is oxyfuel welding or oxyacetylene welding.
- The equipment is relatively inexpensive and simple.
- Generally employing the combustion of acetylene in oxygen to produce a welding flame temp of about 3100 deg centigrade.
- The flame, since it is less concentrated than an electric arc, causes slower weld cooling, which can lead to greater residual stresses and weld distortion.
- Oxyfuel coating is used to cut the metal.
- It is also useful in plastic welding, though the heated substance is air, and the temp are much lower.

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Gas welding process:
RESISTANCE WELDING:

- It involves the generation of heat by passing current through the resistance caused by the contact between two or more metal surfaces.
- Small pools of molten metal are formed at the weld area as high current (1000-100,000) is passed through the metal.
- This method is efficient and causes little pollution.
- Application is limited and equipment cost is high.
- Spot welding is a popular resistance welding method used to join overlapping metal sheets up to 3mm thick.
- Advantages: efficient energy usage; limited workpiece deformation; high production rate; easy automation; no require filler material; application limited only in the automotive industry and it is done by industrial robots.
- Disadvantage: weld strength is significantly lower than with other welding.

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EQUIPMENT USED IN RESISTANT WELDING:
ENERGY BEAM:

- TYPES:
  a. laser beam welding:
    > employs a highly focused laser beam.
  b. electron beam welding:
    > it is done in vacuum with the use of electron beam.

Advantages:
> both are having very high energy density making deep weld penetration and minimize the size of weld area.
> both process are extremely high and easily automated, making them productive.

Disadvantages:
> the cost is high and thermal cracking may be occurred.
SOLID STATE WELDING (ultrasonic):

- Ultrasonic welding is used to connect thin sheets or wire made of metal or thermoplastic by vibrating them at high frequency and under high pressure.
- The equipment used is very similar to the resistance welding, but instead of electric current, vibration provides energy inputs.
- Process doesn't involve melting the materials; instead, the weld is formed by introducing mechanical vibrations horizontally under pressure.
- It is used for making an electrical connection out of alumina or copper.
EXPLOSIVE WELDING:

- It involves the joining of materials by pushing them together under extremely high pressure.
- The energy from the impact plasticizes the materials, forming a weld, even though only a limited amount of heat is generated.
- The process is commonly used for welding dissimilar materials, such as the welding of aluminum with steel in ship or compound plates.
- Other similar process is co-extrusion welding, cold welding, high frequency welding, hot pressure welding, and roll welding.

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ELECTRODE:

- Basically electrode is used very similar to the base metal, but sometimes different metal electrode is used as per the material composition.
- Coating consists of a number of different compounds, including rutile, calcium fluoride, cellulose, and iron powder.
- Electrode is being used as per the AWS standard, for example, E6010, E6012, E6013, and E7014, etc.
  
  E- electrode, 60- tensile strength in thousand pound per square, 1 or 2- position.

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VARIOUS TYPES OF ELECTRODE

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EQUIPMENT:

- ELECTRODE
- STEP DOWN TRANSFORMER
- GENERATOR/ALTERNATOR
- FILLER MATERIAL
- GAS CYLINDER, etc.

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SAFETY:

Arc welding with a welding helmet, gloves, and other protective clothing.

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UNUSUAL CONDITION OF WELDING:

Underwater welding

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METALLURGY INVOLVED IN WELDING:

- PREHEATING
- POSTHEATING
- ANELING
- TEMPERING
- MASTEMPERING
- NORMALISING
- AUSTEMPERING, etc.

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Heat affected zone (HAZ):
WELDING INSPECTION:

inspection of welds and welded assemblies involves:

• Dimensional inspection
• Non-destructive examination
• Welding processes
• Welding metallurgy
• Destructive testing
• Welding procedure
• Welder and
• Welding operating qualification requirements.

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INSPECTION PROCEDURE:

01. PRIOR TO WELDING
   - material identification, chemical analysis, mechanical properties.

02. Base metal discontinuities
    - lamination and cracks, surface irregularities, flatness.

03. GEOMETRY
    - edge preparation, dimensions, cleanliness, root opening, tacking.

04. DURING WELDING
    - preheat and interpass temperatures control, measurements.

05. FILLER METAL
    - identification, control, handling.

06. ROOT PASS
    - contour, soundness.

07. AFTER WELDING
    - post heat treatment requirements

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ACCEPTANCE INSPECTION:

- Method of cleaning for inspection
- NDT
- Visual inspection
- Conformity of welds with drawing
- Magnetic particle and liquid penetrant tests
- Radiography
- Ultrasonic test
- Proof testing
- Other suitable methods.
- Destructive testing

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NDT METHODS:

- Visual inspection
- Radiography
- Ultrasonic examination
- Magnetic particle test
- Penetrant testing
- Eddy current testing
- Acoustic emission testing
- Ferrite determination.

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WELDING DEFECTS:

- Weld discontinuities
- Cracks
- Porosity
- Seams
- Fusion
- Alloy content
- Heat treatment variations
- Wall thickness
- Internal cracking during cooling
- Slag corrosion
- Dimensional defects
- Fit-up defects, etc.
THANKS

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Questions?