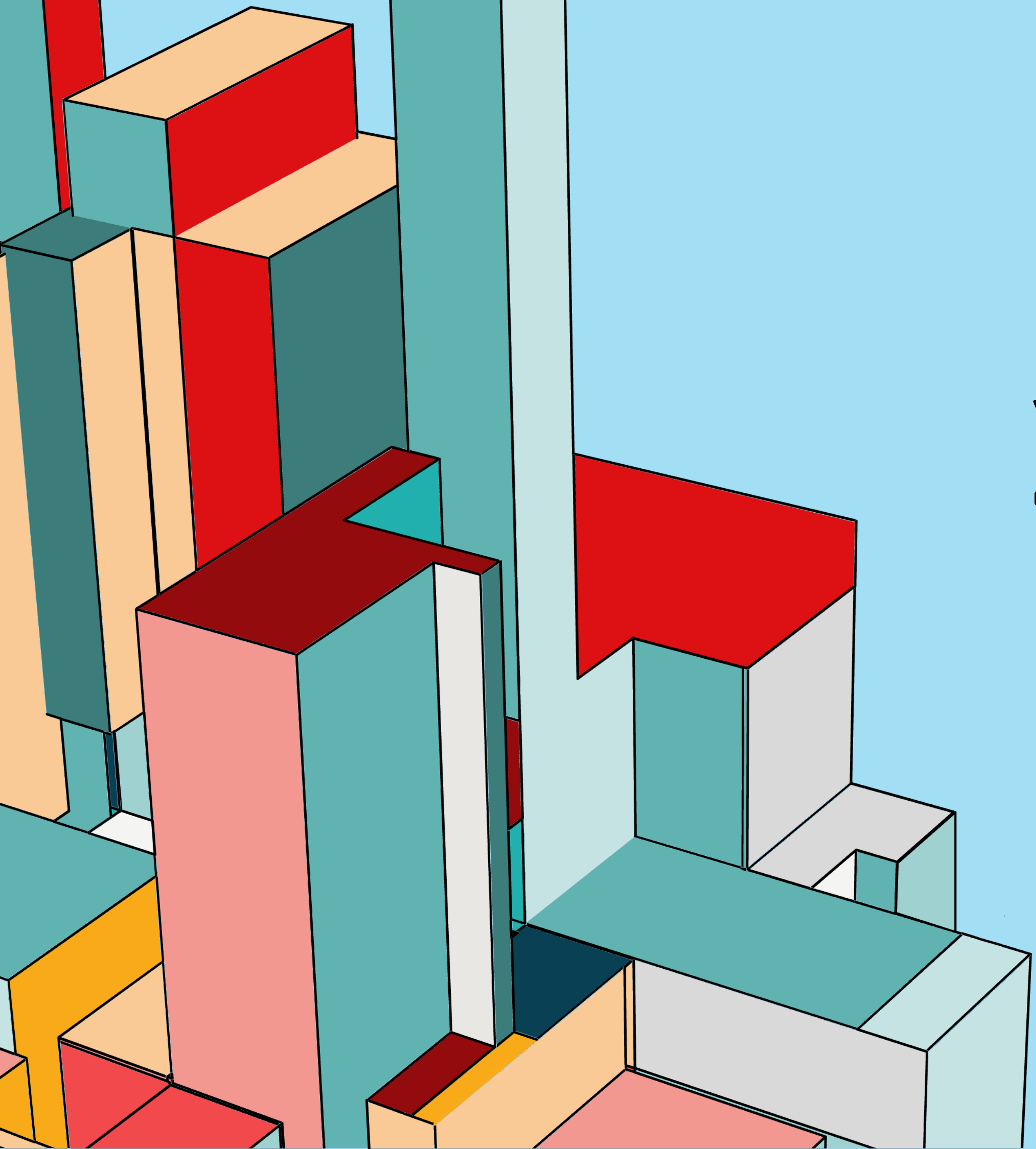
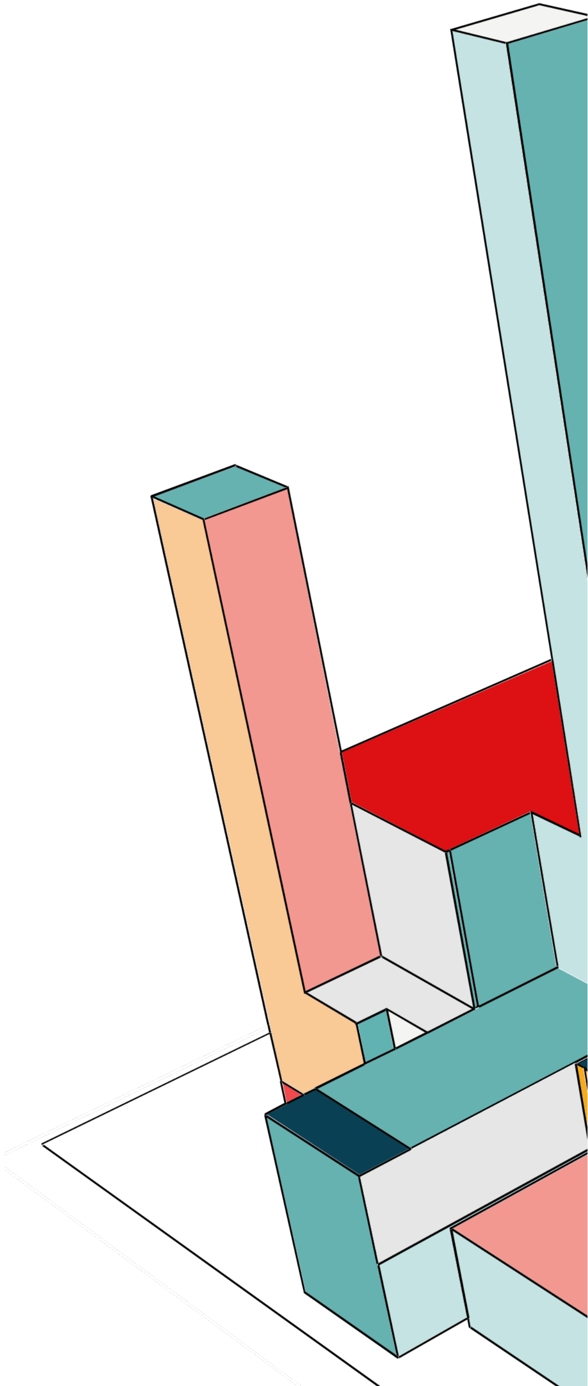


WELDING DEFECTS – TYPES ,CAUSES AND PREVENTION

WELDING-TOPICS

- Introduction
- Types of welding
- Defects in welding
- Welding testings

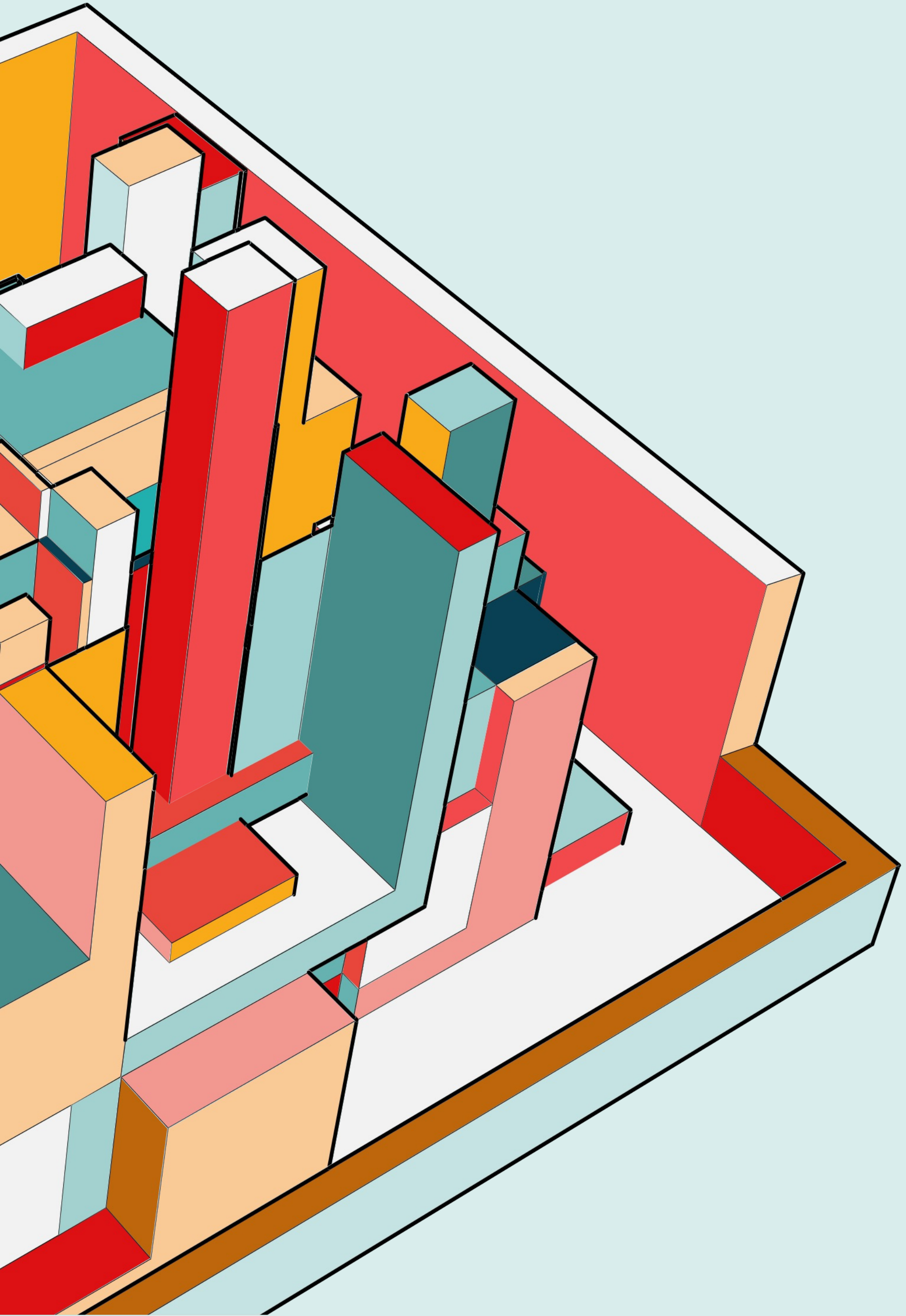


WHAT IS WELDING?

WELDING

- The Welding is a process of Joining Two or more, Similar or dissimilar metals by heating them to a suitable Temperature, with or without the application of pressure, filler materials and flux.

- Welding is used for making permanent joints.



TYPES OF WELDING

TYPES OF WELDING

The four main type of welding are-

✓GMAW – Gas Metal Arc Welding

✓SMAW – Shielded Metal Arc Welding

✓GTAW – Gas Tungsten Arc Welding

✓FCAW – Flux Cored Arc Welding

GMAW-GAS METAL ARC WELDING

Gas metal arc welding (GMAW), is a welding process in which an electric arc forms between a consumable MIG (Metal Inert Gas) wire electrode and the workpiece metal(s), which heats the workpiece metal(s), causing them to fuse (melt and join). Along with the wire electrode, a shielding gas feeds through the welding gun, which shields the process from atmospheric contamination.

Advantages

- No Flux so No Slag
- No requirement of Special fixtures
- Faster weld speed
- Less Skilled Operator Required

Limitations

- More Spatter
- Poor Weld Appearance
- Less Penetration
- Effecting Shielding is Required
- Limited Welding Position

GMAW-GAS METAL ARC WELDING

Electrodes

MATERIAL	TYPICAL ELECTRODE
CS/MS	ER70S-6
SS	ER308L
CS#SS	ER309L
CS#C276 (HASTE- ALLOY)	ERNiCrMO-4

Equipment cost - Relatively Costly

Welding Speed - 2.5 to 3 times more than SMAW

SMAW – SHIELDED METAL ARC WELDING

An electric current, in the form of either alternating current or direct current from a welding power supply, is used to form an electric arc between the electrode and the metals to be joined. The workpiece and the electrode melts forming a pool of molten metal (weld pool) that cools to form a joint. As the weld is laid, the flux coating of the electrode disintegrates, giving off vapors that serve as a shielding gas and providing a layer of slag, both of which protect the weld area from atmospheric contamination.

Advantages

- Simple Equipment's & Portable
- All Position Welds
- Accessibility

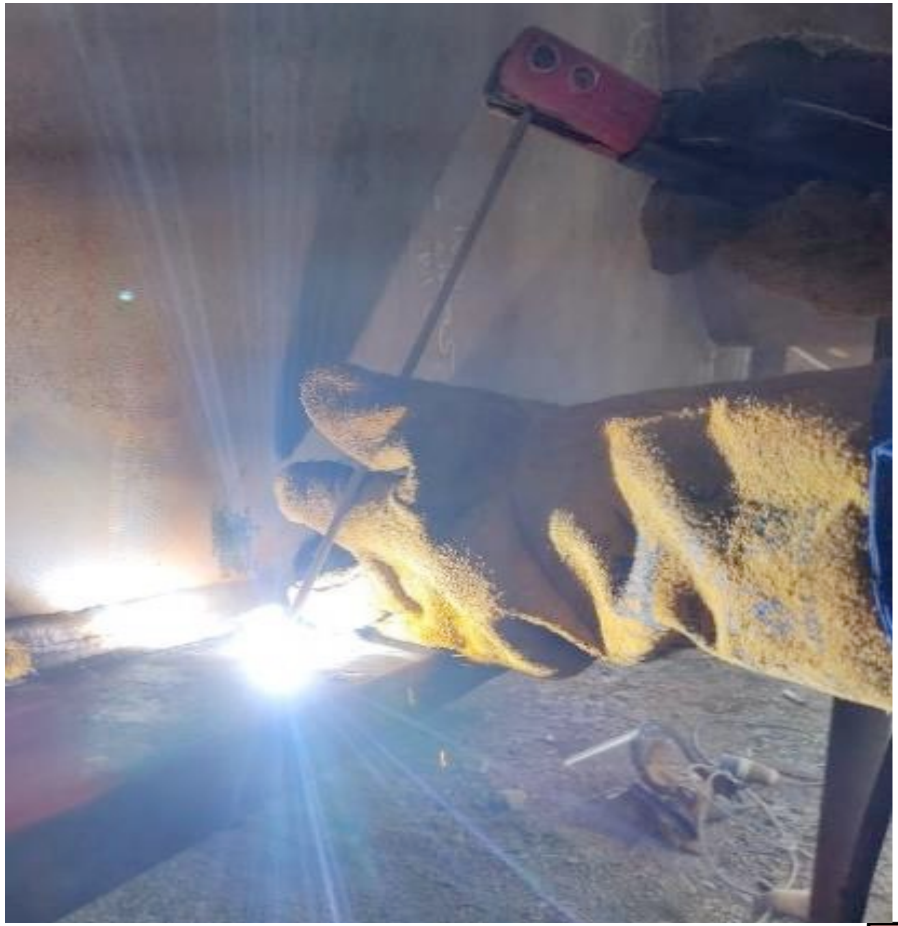
Limitations

- Less Speed
- Manual Control
- Arc Initiation requires more skill

SMAW – SHIELDED METAL ARC WELDING

Electrodes

MATERIAL	TYPICAL ELECTRODE
CS	E7018-1
SS	E308L-16
CS#SS	E309L-16
MS	E6013



Equipment cost - Normal
Welding Speed - Normal

GTAW- GAS TUNGSTEN ARC WELDING

Gas tungsten arc welding (GTAW), also known as tungsten inert gas (TIG) welding, is an arc welding process that uses a non-consumable tungsten electrode to produce the weld. The weld area and electrode are protected from oxidation or other atmospheric contamination by an inert shielding gas (argon or helium). A filler metal is normally used, though some welds, known as autogenous welds, or fusion welds do not require it. When helium is used, this is known as heliarc welding

Advantages

- No flux required so No slag
- All position
- Suitable for thin metals
- High quality root

Limitations

- Slow Welding Speed
- Tungsten inclusion possibility in weld metal
- Requirement of inert Gas purging and Shielding
- High skilled welders required

GTAW- GAS TUNGSTEN ARC WELDING

Electrodes

MATERIAL	TYPICAL ELECTRODE
CS/MS	ER70S-2
SS	ER308L
CS#SS	ER309L
CS#C276 (HASTE ALLOY)	ERNiCrMO-4

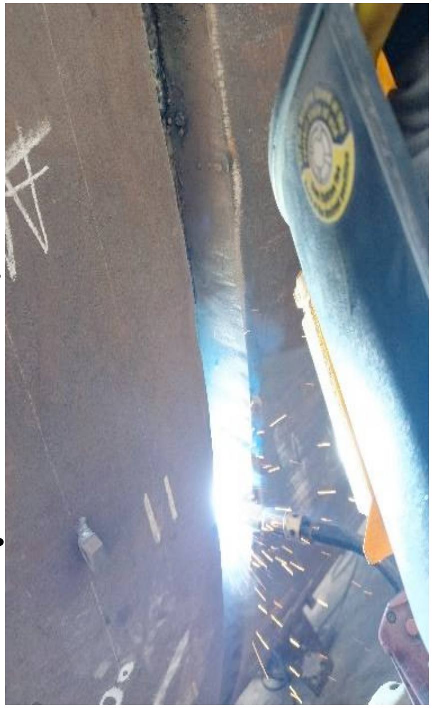
Equipment cost - Relatively Costly
Welding Speed - Slow

FCAW- FLUX CORED ARC WELDING

Flux-cored arc welding (FCAW or FCA) is a semi-automatic or automatic arc welding process. FCAW requires a continuously-fed consumable tubular electrode containing a flux and a constant-voltage or, less commonly, a constant-current welding power supply. An externally supplied shielding gas is sometimes used, but often the flux itself is relied upon to generate the necessary protection from the atmosphere, producing both gaseous protection and liquid slag protecting the weld.

Advantages

- Yields high quality, consistent welds with fewer defects
- High deposition rate.
- Can be used in all positions with the right filler metal.
- Relatively easy to learn compared to other welding processes.
- Allows for high welding productivity



Limitations

- A high level of noxious fumes which must be ventilated.
- Higher electrode wire cost compared to solid electrode wires.
- More costly equipment than many other welding processes.
- Less portable equipment than SMAW or GTAW.
- The slag covering the weld must be removed.

FCAW- FLUX CORED ARC WELDING

Electrodes

MATERIAL	TYPICAL ELECTRODE
CS/MS	E71T-1C
SS	E308LT1-1
CS#SS	E309LT0-1
CS#C276 (HASTE ALLOY)	ERNiCrMo-4

Equipment cost - Relatively Costly
Welding Speed -More than SMAW

WELDING DEFECTS

A weld defect results from a poor weld, weakening the joint. It is defined as the point beyond the acceptable tolerance in the welding process.

Imperfections may arise dimensionally, wherein the result is not up to standard. They may also take place in the form of discontinuity or in material properties. Common causes of welding defects come from incorrect welding patterns, material selection, skill, or machine settings, including welding speed, current, and voltage.

When a welded metal has a welding defect present, there are multiple options for resolving the issue. In some cases, the metal can be repaired, but at other times the metal itself has melted and the welding procedure needs to be restarted.

Weld irregularities occur for a variety of reasons and it results in different welding defects. They can be classified into two major categories: **internal welding defects** and **external welding defects.**

External Welding Defects

External welding defects refer to discontinuities in the weld metal that are noticeable to the naked eye.

- ✓ Cracks
- ✓ Porosity
- ✓ Undercut
- ✓ Overlap
- ✓ Burn-Through
- ✓ Spatter
- ✓ Under Filled
- ✓ Excess Reinforcement
- ✓ Mechanical Damage
- ✓ Distortion
- ✓ Misalignment

CRACKS

Cracks are the worst welding defect since they can rapidly progress to larger ones, which inevitably leads to failure. Weld cracks are mainly classified depending on how they form in the weld bead.

Longitudinal cracks form parallel to the weld bead while transverse cracks form across the width. Crater cracks form at the end of the bead, where the arc concludes.

Causes

- Using hydrogen shielding gas in welding ferrous metals.
- Ductile base metal and the application of residual stress.
- Rigid joints that constrain the expansion and contraction of the metal.
- Use of high levels of Sulphur and carbon.

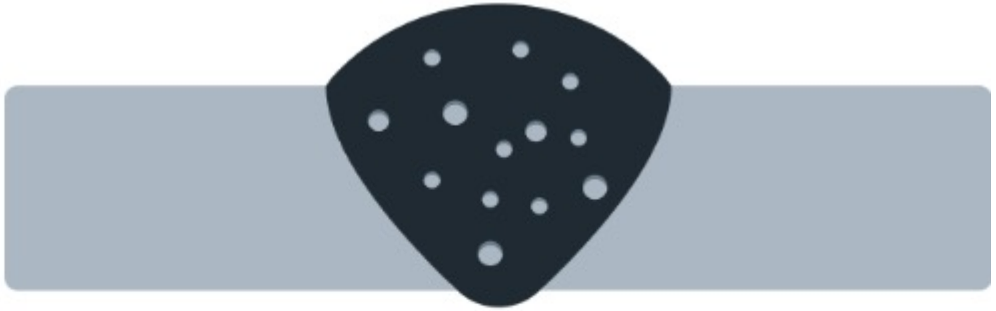
Prevention

- Preheating the metals and gradually cooling the weld joints
- Maintaining acceptable weld joint gaps.
- Selection of the correct welding materials.

POROSITY

Porosity is the formation of holes in the weld pool resulting from gas bubbles that cannot escape. It is usually one of the common welding defects when using shielding gas, which is present in welding techniques such as TIG and stick welding. Absence, lack, or too much shielding gas may lead to metal contamination, which reduces the strength of the weld.
On the other hand, severe versions of porosity come in the form of blow holes or pits when large gas bubbles get trapped in the weld pool. Additionally, smaller gas molecules can blend with the weld metal, forming an impure compound.

Causes



- Unclean welding surface.
- Wrong electrode selection.
- Lack or absence of shielding gas.
- Either too low or too high welding current.

Prevention

- Cleaning the weld surface.
- Using the correct welding electrode.
- Preheating the metals before welding.
- Proper gas flow rate setting to achieve the right amount of shielding.

UNDERCUT

An undercut can be formed in various ways but mainly it is tied to two reasons. The first is using excessive current – the edges of the joint melt and drain into the weld. The second reason is not that enough filler metal is deposited into the weld. This results in a reduced cross-section meaning that there are notches or grooves along the weld, which increase stress when the material is subjected to fatigue loading. This defect occurs at the toe of the weld or in the case of multi-run welds, in the fusion face. An undercut may come from continuous, intermediate, and inter-run.

Causes

- High arc voltage.
- Incorrect electrode selection or wrong electrode angl
- High travel speed.

Prevention

- Smaller arc length, voltage, and travel speed.
- 30 to 45-degree electrode angle.
- Reducing the electrode diameter.

OVERLAP

Overlap is the excess metal that spreads out around the bead. The spread-out filler metal is not properly mixed with the base metals. Typically, it comes in a round shape over the weld joint..

Causes

- Incorrect welding procedure.
- Wrong selection of welding materials.
- Improper preparation of base metals.

Prevention

- Smaller welding current.
- Use of proper welding techniques.
- Shorter welding electrode.

BURN-THROUGH

An open hole is exposed when the welding process accidentally penetrates the whole thickness of the base metal, creating a burn-through or melt-through. This is one of the common weld defects when welding thin metals.

Causes

- High welding current.
- Extreme gap to the root.
- Not enough root face metal.

Prevention

- Maintaining a proper root gap.
- Control in the application of welding current.
- It can be repaired in some cases wherein the hole is removed and re-welded.

SPATTER

Spatter is a welding defect that occurs when metal droplets are discharged on the metal surface. It solidifies and becomes stuck on the metal surface once it cools down. In most cases, spatter does not alter the structural integrity of the weld but generally, it has to be removed, adding to the total costs.

Causes

- High arc length.
- High welding current.
- Improper shielding of the heat-affected zone.
- Using the wrong polarity may create excessive spatter.

Prevention

- Choosing the correct weld polarity.
- Selecting a better shielding gas and better shielding technique.
- Reducing the welding current and arc length to optimal condition.

UNDER-FILLED

Underfill occurs when too little weld metal is deposited into the joint. As a result, some of the parent material remains unfused and the joint is under filled. These unfused sections, even when small, act as potential stress raisers.

Causes

- Low welding current.
- Too high travel speeds.
- Incorrect weld bead placement.
- Laying weld beads too thinly in multi-pass welds.

Prevention

- Proper electrode size selection.
- Selecting the right current setting.
- Avoid moving too fast.

EXCESS REINFORCEMENT

Excess reinforcement (overfilled) describes a weld that has too much build-up. It is the opposite of underfilled welds as excessive amounts of filler metal is deposited into the joint. With this defect, high levels of stress concentration build up in the toes of the welds.

Causes

- Low travel speeds.
- Incorrect procedures.
- Excess flux on the feed wire.

Prevention

- Maintaining an optimal pace with the torch.
- Avoiding excess heat by making sure to use the correct voltage and amperage.
- Aligning the workpieces properly to ensure that the gap between the parts is not too large.

MECHANICAL DAMAGE

Mechanical damage is indentations present in the weld due to damage from preparation, handling, welding, equipment usage, and other factors.

Causes

- Unnecessary application of external force before, during, or after an operation.
- Incorrect handling of welding equipment
- Not engaging the arc before the welding procedure

Prevention

- Safe and correct handling of welding equipment.
- Consistently engaging the arc in the metal parts before starting welding.

DISTORTION

Distortion or warping is an accidental change in the shape of the surrounding metal of the weld. Excessive heating around the weld joint is the main reason for distortion around its area. Warpage or distortion mostly occurs in thin metals and is classified into four types: angular, longitudinal, fillet, and neutral axis.

Causes

- Thin weld metal.
- Incompatible base metal and weld metal.
- High amount of weld passes.

Prevention

- Using suitable weld metals.
- Optimizing the number of weld passes.
- Selection of better welding methods for the metal type.

MISALIGNMENT

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Causes

- Thin weld metal.
- Incompatible base metal and weld metal.
- High amount of weld passes.

Prevention

- Using suitable weld metals.
- Optimizing the number of weld passes.
- Selection of better welding methods for the metal type.

SLAG INCLUSION

A weld bead that contains slag in its composition compromises the toughness and structure of the metal. Slag inclusion may occur either on just the surface of the weld metal or in between welding cycles. This weld defect is common to processes that use flux, such as stick, flux-cored, submerged arc welding, and brazing.

Causes

- Incorrect welding angle and travel speed of the welding torch.
- Poor pre-cleaning of the edge of the weld surface.
- Low welding current density resulting in inadequate heating of the metals.

Prevention

- Higher welding current density.
- Optimal welding angle and travel speed to avoid slag inclusion in the weld pool.
- Consistent weld edge cleaning and slag removal of each layer.

INCOMPLETE FUSION

Incomplete fusion results from poor welding wherein the metals pre-solidify, forming gaps in the weld zone. When the welder cannot properly melt the parent metal with the base metal, it results in a lack of fusion.

Causes

- ➢ Low heat input resulting in metals not melting.
- ➢ Wrong joint angle, torch angle, and bead position.
- ➢ Extremely large weld pool.

Prevention

- ➢ Higher welding current and slower travel rate to ensure the melting process of the metals.
- ➢ Improving welding positions such as joint angle, torch angle, and bead position.
- ➢ Lower deposition rate.

INCOMPLETE PENETRATION

Incomplete penetration generally occurs during butt welding, wherein the gap between the metals isn't filled completely through the joint thickness. This means that one side of the joint is not fused in the root.

Causes

- Incorrect use of the welding technique.
- Wrong electrode size.
- Low deposition rate.

Prevention

- Using the correct welding technique and procedure.
- Higher deposition rate.
- Proper electrode size selection.

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Prevention

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- Higher deposition rate.
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NECKLACE CRACKING

Necklace cracking is a welding defect associated with electron beam welding. This defect occurs when the molten metal can't sufficiently flow into the cavity, resulting in incomplete penetration.

Causes

- Using metals such as stainless steel, carbon steel, tin, and nickel-based alloys.
- Improper welding technique application.
- High operation speed in electron beam welding.

Prevention

- Snipping Using metals such as stainless steel, carbon steel, tin, and nickel-based alloys.
- Improper welding technique application.
- High operation speed in electron beam welding.

HOW TO DETECT WELDING DEFECTS

Testing methods are a great way to check if the welding patterns meet specific criteria. It allows us to find the causes and remedies for why welding defects occur. While it takes some time, it ensures that the welds are safe and risk-free.

There are two standard procedures for finding defects in a weld metal:

- Non-Destructive Testing
- Destructive Testing

NDT – (NON DESTRUCTIVE TESTING)

Non-destructive testing allows us to observe discontinuities in the weld incurring no damage. This testing method is essential in high-speed production wherein a sample is tested from a batch.

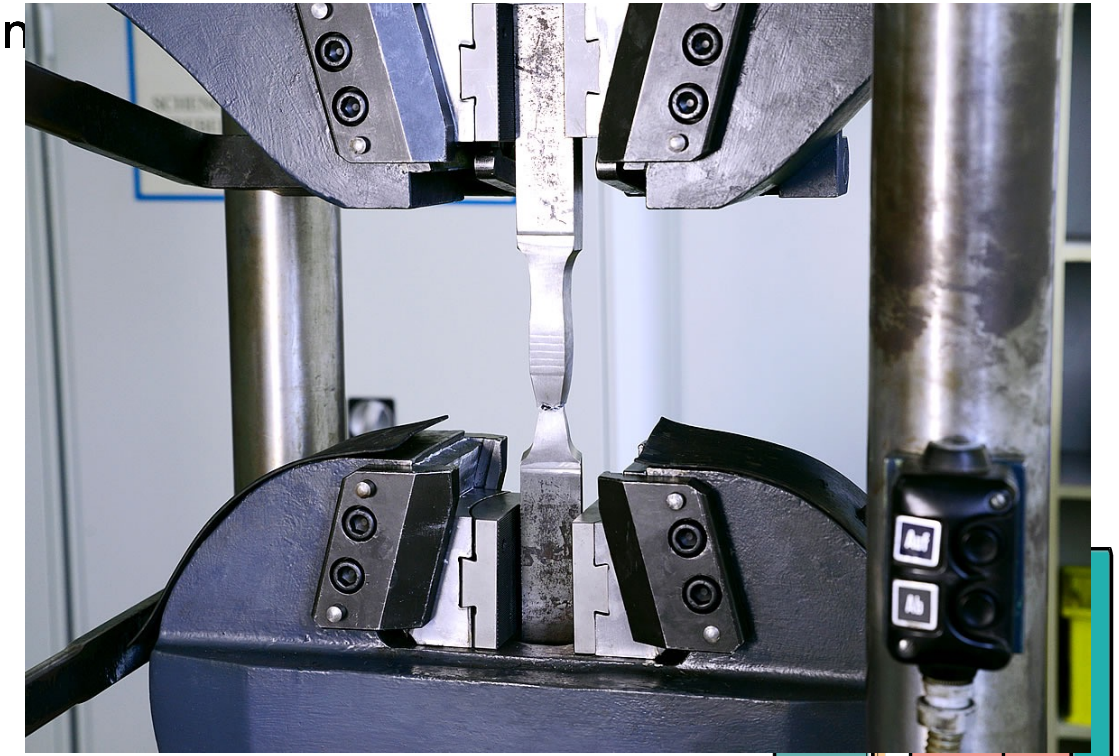
The most common welding NDT methods-

- Ultrasonic testing NDT.
- Magnetic particle inspection NDT.
- Dye penetrant NDT.
- Radiography NDT.
- Visual NDT

DT – (DESTRUCTIVE TESTING)

Destructive testing acquires information by subjecting the finished projects to strenuous methods until it reaches their limits. Some cases require destructive testing in addition to non-destructive tests in order to reduce weld defects in production significantly.

Some destructive methods used to identify the limits of the weld metal are acid etch, guided bend, free bend, back bend, nick break, and tensile stren



The most common Destructive methods-

- Tensile strength
- Bend Test
- Impact Test
- Hardness Testing
- Corrosion Testing

THANK YOU