

## WELD DEFECTS AND THEIR IMPLICATIONS ON WELD STRUCTURE

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**Abstract-** Welding is a process of joining metals or thermoplastics, by using high heat to melt the parts together and allow them to cool causing fusion. Welding is different from other metal joining process like as brazing and soldering which are usually done at lower temperatures without melting the base metal. We basically concentrated on the weld defects which are occurred during and after welding process. Types of testing which are destructive testing and Non-destructive testing (NDT) are performed. With the help of Dye-penetrant inspection the welding defects has been identified for T-Joint and Butt joint. The process involved in Dye-Penetrant inspection are pre-cleaning, application of penetrant, excess penetrant removal, application of developer, inspection, post cleaning.

**Keywords:** Welding, defects, inspection, non-destructive testing, penetration.

### 1. Introduction

Welding Defects can be defined as the irregularities formed in the given weld metal due to wrong welding process or incorrect welding patterns, etc. The defect may differ from the desired weld bead shape, size, and intended quality. Welding defects may occur either outside or inside the weld metal. Some of the defects may be allowed if the defects are under permissible limits but other defects such as cracks are never accepted.

Welding defects can be classified into two types as external and internal defects:

#### External Welding Defects:

- 1.WeldCrack
- 2.Undercut
- 3.Spatter
- 4.Porosity
- 5.Overlap
6. Crater

#### Internal Welding Defects:

- 1.SlagInclusion
- 2.IncompleteFusion
- 3.Necklacecracking
- 4.Incompletely filled groove or incomplete penetration

**Weld Crack**-This is the most unwanted defect of all the other welding defects. Welding cracks can be present in the surface, inside of the weld material or at the hewst effected zone.

**Hot Crack** - It is more prominent during crystallization of weld joints where the temperature can rise more than 10,000-degree Celsius.

**Cold Crack** - This type of crack occurs at the end of the welding process where the temperature is quite low. Sometimes cold crack is visible several hours after welding or even after few days.



**Fig -1:** Cracking

**Undercut-** When the base of metal melts away from the weld zone, then a groove is formed in the shape of a notch, then this type of defect is known as Undercut. It reduces the fatigue strength of the joint.

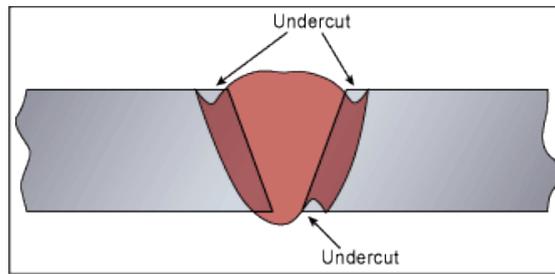


Fig -2: Undercut

**Spatter-** When some metal drops are expelled from the weld and remain stuck to the surface, then this defect is known as Spatter.



Fig -2: Spatter

**Porosity-** Porosity in the condition in which the gas or small bubbles gets trapped in the welded zone.



Fig -3: Porosity

**Overlap-** When the weld face extends beyond the weld toe, then this defect occurs. In this condition the weld metal rolls and forms an angle less than 90 degrees.

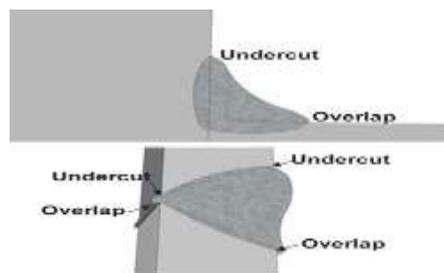


Fig -4: Overlap

**Crater-** It occurs when the crater is not filled before the arc is broken, which causes the outer edges to cool faster than the crater. This causes a stress and then a crack is formed.

**Slag Inclusion-** If there is any slag in the weld, then it affects the toughness and metal weldability of the given material. This decreases the structural performance of the weld material. Slag is formed on the surface of the weld or between the welding turns.



Fig -5: Slag Inclusion

**Incomplete Fusion-** Incomplete fusion occurs when the welder does not accurately weld the material and the metal pre solidifies which leads to a gap which is not filled with the molten metal.

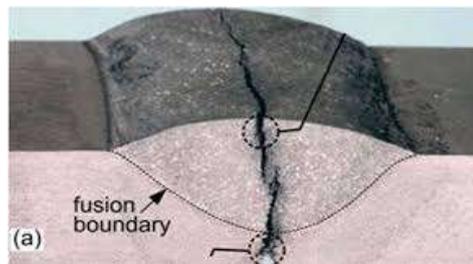


Fig -6: Incomplete Fusion

**Necklace Cracking-** It occurs in the use of electron beam welding where the weld does not penetrate properly. Therefore, the molten metal does not flow into the cavity and results in a cracking known as “Necklace Cracking”.



Fig -7: Porosity

**Incompletely Filled Groove or Incomplete Penetration-** These defects occur only in the butt welds where the groove of the metal is not filled completely. It is also called as incomplete penetration defect.

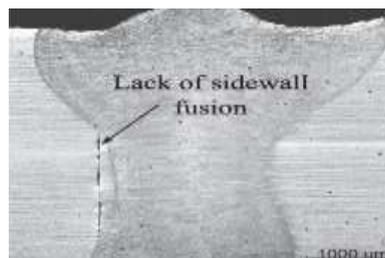


Fig -8: Incomplete Penetration

## 2. Non-Destructive Testing:

Non-destructive testing (NDT) is a wide group of analysis techniques used in science and technology industry to evaluate the properties of a material, component or system without causing damage. The terms non-destructive examination (NDE), non-destructive inspection (NDI), and non-destructive evaluation (NDE) are also commonly used to describe this technology. Because NDT does not permanently alter the article being inspected, it is a highly valuable technique that can save both money and time in product evaluation, troubleshooting, and research.

The six most frequently used NDT methods are eddy-current, magnetic-particle, liquid penetrant, radiographic, ultrasonic, and visual testing. NDT is commonly used in forensic engineering, mechanical engineering, petroleum engineering, electrical engineering etc.

**Dye penetrant inspection process is adopted to know the weld defects in the weld-** Dye penetrant inspection (DP), also called liquid penetrant 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.

## 3. Steps involved

Below are the main steps of Liquid Penetrant Inspection:

The test surface is cleaned to remove any dirt, paint, oil, grease or any loose scale that could either keep penetrant out of a defect, or cause irrelevant or false indications. Cleaning methods may include solvents, alkaline cleaning steps, vapor degreasing, or media blasting. The end goal of this step is a clean surface where any defects present are open to the surface, dry, and free of contamination. Note that if media blasting is used, it may "work over" a small discontinuity in the part and an etching bath is recommended as a post-blasting treatment.



**Fig -8:** Pre-cleaning

The penetrant is then applied to the surface of the item being tested. The penetrant is usually a brilliant coloured mobile fluid with high wetting capability. The penetrant is allowed "dwell time" to soak into any flaws (generally 5 to 30 minutes). The dwell time mainly depends upon the penetrant being used, material being tested and the size of flaws sought. As expected, smaller flaws require a longer penetration time. Due to their incompatible nature one must be careful not to apply solvent-based penetrant to a surface which is to be inspected with a water-washable penetrant.



**Fig -9:** Application of Penetrant

The excess penetrant is then removed from the surface. The removal method is controlled by the type of penetrant used. Water-washable, solvent-removable, lipophilic post-emulsifiable, or hydrophilic post-emulsifiable are the common choices. Emulsifiers represent the highest sensitivity level, and chemically interact with the oily penetrant to make it removable with a water spray. When using solvent remover and lint-free cloth it is important to not spray the solvent on the test surface directly, because this can remove the penetrant from the flaws. If excess penetrant is not properly removed, once the developer is applied, it may leave a background in the developed area that can mask indications or defects. In addition, this may also produce false indications severely hindering the ability to do a proper inspection. Also, the removal of excessive penetrant is done towards one direction either vertically or horizontally as the case may be.



**Fig -10:** Excess Penetrant Removal

After excess penetrant has been removed, a white developer is applied to the sample. Several developer types are available, including: non-aqueous wet developer, dry powder, water-suspendable, and water-soluble. Choice of developer is governed by penetrant compatibility (one can't use water-soluble or suspendable developer with water-washable penetrant), and by inspection conditions. When using non-aqueous wet developer (NAWD) or dry powder, the sample must be dried prior to application, while soluble and suspendable developers are applied with the part still wet from the previous step. NAWD is commercially available in aerosol spray cans, and may employ acetone, isopropyl alcohol, or a propellant that is a combination of the two. Developer should form a semi-transparent, even coating on the surface.



**Fig -11:** Application of Developer

The developer draws penetrant from defects out onto the surface to form a visible indication, commonly known as bleed-out. Any areas that bleed out can indicate the location, orientation and possible types of defects on the surface. Interpreting the results and characterizing defects from the indications found may require some training and/or experience [the indication size is not the actual size of the defect].

**Inspection-** The inspector will use visible light with adequate intensity (100 foot-candles or 1100 lux is typical) for visible dye penetrant. Ultraviolet (UV-A) radiation of adequate intensity (1,000 micro-watts per centi-meter squared is common), along with low ambient light levels (less than 2 foot-candles) for fluorescent penetrant examinations. Inspection of the test surface should take place after 10- to 30-minute development time, and is dependent on the penetrant and developer used. This time delay allows the blotting action to occur. The inspector may observe the sample for indication formation when using visible dye. It is also good practice to observe indications as they form because the characteristics of the bleed out are a significant part of interpretation characterization of flaws.

**Post Cleaning-** The test surface is often cleaned after inspection and recording of defects, especially if post-inspection coating processes are scheduled.

#### 4. Result

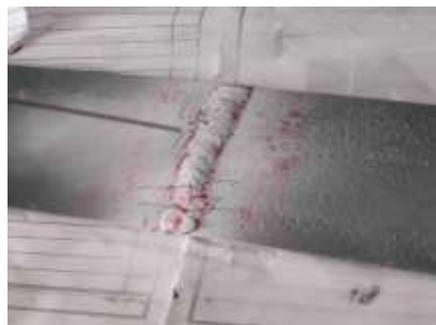
Below Results will show the weld defects in T-Joint:



**Fig -12:** T-Joint

- Lack of Fusion
- Improper welding
- Porosity
- Pinhole

Below results will show the weld defects occurred in Butt joint:



**Fig -13:** Butt Joint

- Undercut
- Shrinkage
- Porosity
- Under fill
- Root Concavity
- Cracks

#### 5. Conclusion

The problems arise due to weld defects are determined; the operator can easily correct the problem. Defects usually encountered include incomplete penetration, incomplete fusion, under cutting, porosity, and longitudinal cracking.

**To overcome defects:** Prevent these types of weld defects by using the right metal. You will need to remove the impurities in your metal and preheat it as required. additionally, use the proper joint design for the material and properly cool the weld area. Be sure to weld enough sectional areas too.

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