Analysis of various defects involved in welding metallurgy

Sonit Singh
UG Student, School of Mechanical Engineering, KIIT University, Patia, Bhubaneswar, Odisha -751024
Email: Corresponding author: 1602338@kiit.ac.in

July 14, 2018

Abstract
Any mechanical structure or system weather be it a bridge,dam,mechanized tools or any sort of machine that helps to reduce human efforts demands high quality materials which must impose strength,reliability and ductility for better construction. It must also possess adequate elasticity and plasticity properties and many several other properties which may incorporate the best material for use. In order to meet the demands of the market in this fast moving world and rapid urbanization, it is not easy to have a mass production and also good quality materials for the products at the same time. Hence the principle of interchangeability comes into play which plays an important role in the globalization of mass production in this rapid moving world. Since companies are aiming for constant production of impecable products, the focus shifts towards the manufacturing management at the earliest of stages where the development of proper mating parts and elements which form the structural unit of a product (machine) takes place. Welding is one such straightforward process of the basic manufacturing and hence grabs the center of attention for this paper. In order to produce better products, welding plays a crucial role. But any manufacturing process may inherit various defects which can greatly affect longevity. This paper focuses
on the various defects that can occur during welding and the remedies to correct it.

Keywords: Skin cancer, ABCD features, GMM, Dermo-scopic Image

1 Introduction to Welding

Welding is defined as a manufacturing process which facilitates the formation of metallic bonds between two similar or different metals in order to establish a permanent fitting between them. It is referred to as the art of joining or providing coalescence between the materials by subjecting them to pressure or by heat fusion. Welding has applications in almost all mechanical industries such as automobiles, ship building and various other mechanical frames and structures [1].

2 Classification of Welding

Welding is broadly classified into two categories -

1. Pressure Welding
2. Fusion Welding

Pressure Welding is also known as plastic welding because in this the metals acquire plastic deformations when subjected to external pressure or heating. In this process, the joining of metals takes place below the freezing point of the base metal without the addition of extra filling material [2]. The best advantage it has is the retention of the metallic properties of the base metal as it does not
melt during joining.

**Fusion Welding** is that type of welding process in which external applications do not play an effective role during the course of fusion of two metals. This process proceeds by melting and solidification of the metal. Melting of the base metal takes place near a specific joint after heating it to an extent and solidification of the metals takes place.

### 3 Types of Welding

1. Gas welding
2. Arc welding
3. Thermal and Chemical welding
4. Resistance welding
5. Newer welding techniques (electron beam, laser)

![Fig 1: Welding processes](image)

### 4 Definition of Welding Defects

The defects are those unwanted irregularities or discontinuities produced during the welding of a metal which is beyond the accepted standardized limits and hence can eventually cause the metal to fail. It arises due to many factors like -
1. Poor environmental conditions
2. Incorrect welding parameters or applications
3. Incorrect combination of the filler metal with the base metal

It affects the weldability of the metals and hence decreases the chances of the metal to withstand a certain amount of load, hence not making the welded metal suitable for its satisfactory needs for which it was being designed[3].

5 Classification of welding defects

Before analyzing each and every defect, these defects are classified into two groups-

I) **External or visual defects** are those defects which occur externally at the surface of the weld and can be observed

1. cracking
2. porosity
3. undercut
4. overlap
5. spatter

II) **Internal or hidden** defects are those that occur internally and cannot be observed-

1. slag inclusion
2. lack of fusion
3. incomplete penetration

4. shrinkage cavities

Fig 2. Diagram representation of defects

6 Analysis of External defects

A. Cracking Probably one of the most problematic welding defects is cracking. Cracks may develop on the interior of a weld or at the surface and along many directions. It may also appear on the areas subjected to high temperatures[4]. It destroys the shape and design of the weld and also makes it distorted. It’s hard to observe when cracks develop internally and hence can make the weld less efficient. These defects cannot be overlooked and must be corrected as soon as possible.

Cause

1. Cracking generally takes place due to poor designing of the weld.
2. Prolonged exposure to contraction stresses.
3. Poor metallic properties of the base metal.
4. Due to unequal heating and during thermal shrinkage of the metals.
5. Electrodes having high hydrogen content.

**Remedies**
1. Avoiding instant cooling in order to prevent rapid shrinkage.
2. Equal and Pre-heating from time to time.
3. Electrodes having low hydrogen content.
4. Proper and symmetric designing of the material.
5. Keeping the surface clean before welding.
6. Reducing the gaps in order to prevent cracking during solidification.
7. Using materials having low impurity levels.

**Standard acceptability** There is no acceptability for cracks in welding.

**B. Porosity** It is that type of defect in which the welded area has small groups of voids or gas bubbles trapped inside[5]. They may appear spherical in shape like a small colony of cavities.
Cause

1. When the electrodes during the arc welding process are contaminated with impurities.
2. Accumulation of dirt on the surface of the welded zone.
3. Presence of excess moisture content, grease, and oil.

Remedies

1. Selecting electrodes with a proper coating.
2. Maintaining the arc length.
3. Proper cleaning and decreasing of the moisture content at the surface.

Standard acceptability

C. Undercut During welding, the material has to go through high temperatures and residual stresses due to which it has a tendency to undergo a structural damage. Undercuts are those defects that develop at the welding zone when the base metal melts away forming a depression like groove or a notch and hence can be seen when there is a deep penetration[5]. These defects reduce the strength of the welding joint. It is mainly an arc welding defect.

Cause

1. Due to high voltage applied across the ends of the electrode.
2. When the diameter of the electrode is large.
3. Due to large arc length.
4. Wrong manipulation of the electrode.
5. Accumulation of rust at the surface of the welding joint.

**Remedies**

1. Cleaning of the base material after welding.
2. Avoiding exposure to moisture and hence not allowing the metal to rest.
3. Proper arc and electrode settings.
4. Using a smaller electrode.

**Standard acceptability**  Undercuts are not allowed more than 0.8mm diameter and must not exceed to more than 4-5% depth from the base material.

**D. Overlap**  This kind of defect usually occurs due to poor welding procedures and parameters. Overlapping or the overflow of the welded metal takes place beyond its welded joint or toe.

**Causes**

1. Improper angles of electrode and wrong travel velocities of the arc.
2. Poor welding techniques, procedures and applications.

   Remedies

1. Grinding off the excess metal spill can make the welded joint smooth and repair the overlapping.

2. Using proper and correct welding techniques.

   Standard acceptability Overlapping of the welded joint cannot be accepted.

E. Spatter Spatters are caused due to spilling of the molten metallic drops during welding that stick to the welding surfaces.

Causes

1. Large arc length during arc welding process.

2. Due to rapid solidification.

3. Poor coating of electrodes with different impurity ingredients.

4. Due to establishment of a high welding current across the electrode.

   Remedies

1. Scrapping or cleaning of the product by hair brush or by washing after welding.

2. Proper use of welding equipment.

3. Using correct welding current and arc length.

   Standard acceptability spatters are not accepted in welded products as spatters are easier to remove as well.
7 Analysis of Internal or hidden defects

A. Slag inclusion When impurities, fluxes or many other particles and droplets which can be metallic or sand are entrapped inside the welded zone, inclusions occur which makes the welded metal brittle[6]. It may be present internally, on the surface and across turns. This defect greatly affects the structural design of the metal and affects its weldability and toughness thereby making it more susceptible to fractures[7].

Causes

1. When coating impurities of the electrode enter during welding.

2. Improper welding current and length of the arc.

3. Improper cleaning of the surface.

4. High speed rate of welding.

5. Slag can also occur if the density of current is too small as it may not be able to melt the metal surface entirely.

Remedies

1. Reducing rapid cooling and solidification.

3. Grinding and cleaning of the weld.

**Standard acceptability** Inclusions should exceed more than 3.2mm in diameter approximately after every 5 inches of weld.

**B. Lack of fusion** This type of defect occurs due to the poor technique of the welder who is not able to weld the entire metal[8]. This occurs generally due to early solidification of the welded metal hence there is incomplete fusion of the molten metal in the joint leading to the formation of a gap.

![Lack of Fusion](image)

**Causes**

1. Bad welding technique of the welder.

2. When solidification takes place before due to low supply of heat.

3. The planned weld is not correct or ideal.

4. Small welding current.

**Remedies**

1. Proper cleaning and positioning of the bead.

2. Maintaining the speed and welding current.

3. Proper cleaning and procedures of welding.

4. Re-welding can also avoid such type of errors.

**Standard acceptability** Incomplete fusion is not accepted and hence re-welding must be done.
C. Lack of penetration

Incomplete penetration usually occurs when the molten metal does not extend to the appropriate depth of the root hence leaving behind an incompletely filled groove. It may also lead to the propagation of cracks.

Causes

1. Improper filling of the root gap.
2. When welding metal deposition is low.
3. When electrode diameter is large.
4. Welding done at low temperatures.

Remedies

1. Proper filling of the molten metal.
2. Proper supply of heat.
3. Appropriate functioning and proper diameter of the electrodes.

Standard acceptability

Weld metal should not have any type of penetration.

D. Shrinkage cavities

The last and final defect for this paper. Shrinkage cavities are formed during solidification of the welding metal. The welding metal shrinks during solidification. Allowances must be provided for this defect [9].

Causes

a. It occurs many times during solidification of the metal.

Remedies

a. Deposition of filler metal must be done that can compensate for the loss of metal during shrinking.

Standard acceptability

Shrinking of the metals must be compensated as it may not be able to provide a proper fitting or joining.
References

[1] Mechanical inventions blogspot (Different welding defects)


[3] Effects of defects on strength of welds (Morgan Dundu - Department of civil engineering, University of Johannesburg)


[9] Research and proposal on welding technique for longitudinal crack defect welding Dang Thien Ngon1, *, Phan Van Toan