Overview on Welding Fixtures, Welding Joints, Welding Defects and CO_2 arc welding

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Abstract: *This paper is an over view of the commonly used welding joint's while welding any workpiece. Also, the fixture used, to position the workpiece while welding is discussed. While welding while welding many irregularities, poor weld, imperfections are formed and are classified in many types. The types of welding defects are also part of this paper along with their detection process. And one of the important welding processes i.e. CO_2 arc welding process, the welding in which a consumable filler material used and is used to get deep penetrations while welding, is discussed. Now, different welding conditions have different effects on the weld, this welding conditions can be the metal being welded, forehand/backhand welding, welding velocity, etc.*

Keywords: arc-welding, defects, fixtures, joints, welding, CO_2 arc Welding, conditions

1. Introduction:

Welding is a fabrication process where two or more parts are fused together by applying very high heat and sometimes pressure.

Welding is most important and essential process in industrial world. CO_2 Welding is commonly used in automobile industry, construction industry, fabrication industry, aviation industry, etc.

2. Common Welding Fixtures

2.1 Gas Welding Fixture

In Gas Welding process is done by using the heat flame caused by a reaction of oxygen and fuel gas, metals are melted and joined together. For gas welding if the loss of heat is too rapid the weld will develop many cracks. To provide enough support to weldment, large masses of the fixture are kept away from the welding point.

2.2 Arc Welding Fixture

In arc welding in which electricity is used to create a high temperature for welding, Temperature is higher than the gas welding. The fixture used in arc welding should apply enough force to firmly hold the workpiece, also it should easily dissipate heat. And this fixture should also provide proper alignment as well as support to the work piece.

2.3 Resistance Welding Fixture

For Resistance welding mainly two types of fixture are used first is the combined unit of both machine and the fixture. And second is the fixture to specific welding machines with a single electrode. Insulation plays an important role for fixtures here, all the magnetics, especially ferrous materials should be kept away from the welding machine, and the fixture should be made of non-magnetic materials.

2.4 Laser Welding Fixture

In laser welding a high intensity laser beam is incident, where the welding is needed, this melts the material and thus joins the elements. It is most popularly used where high precision is needed. The fixture should be made such that it prevents the vibration, also height should be maintained properly. And also, there should be sufficient space between the workpiece and other parts to be welded.

3. Some special types of fixture used for specified purposes:

3.1 Welding Fixture for Air filters in automobiles

Air Filters used in automobiles have two fans which need to be welded onto the shell of the filter. The fixture used helps to maintain the eccentricity, height and angle. It has a lower base, supported with four rod this table has a central rod to hold the fan in proper position and also an arrangement made to hold the shell in proper position to maintain the eccentricity. Modeling of fixtures is done using Creo software. This fixture is economical, easy to use, work, has high degree of accuracy, time of operation is reduced.

3.2 Welding Fixture with Active Position Adapting Functions

In today's fast-moving world robotic welding is commonly used. The fixture used for robotic welding needs to be accurate, this will increase the efficiency and quality. This fixture base can tilt rotate along x-axis, can do translation movement and allow rotate along z-axis in relation with slider. The worktable is of hexagonal shape. Also has rack and pinion arrangement along with adjustable clamping to hold the work piece. This fixture helps in clamping workpieces of various sizes and geometries.

3.3 Fixture for the Footrest Stand Component

The fixture is used for the footrest stand, where the component is to be located with high accuracy. This fixture has a rest plate, which has three pins to restrict the movement of the workpiece. There are few locating pads which are used to align and locate the component and fix the bushes accurately. First the bushes are placed accurately using clamps and then are welded round and welded accordingly. Once the welding operation is done, the clamps of the fixture will get detached. Solid works modeling software is used for modeling.

3.4 Fixture for motor case assembly

The motor case is approximately 4m long, it comprises 4 main parts i.e. 2 tubes, rear end and head. Also, some other parts like brackets, clamps need to be mounted. So, fixture design has high accuracy satisfying the above needs. The fixture has a collapsible assembly and roller support assembly to avoid the deflection of the tubes. The fixture has a sequential setup to improve the quality. Also, clamps are provided to achieve appropriate tolerance. The modeling software used for designing elements is UNIGRAPHICS NX 8.0.

3.5 Welding Fixture for a Single Door Frame

The fixture used for the door frame should possess more clinching power, and should hold the door frame rigidly. Also, the clamping used for proper positioning should not restrict the welding and should be easily removable once welding is done. The fixture is made of a base plate and 2 rectangular blocks are mounted to hold each strip of the door frame in rectangular positions. The strips are held together (tightened) using cotters. The fixture is in a slanting position with respect to the surface to get proper welding done. The fixture is portable and has many industrial applications.

3.6 Fixture for Fuel Tank Mounting Bracket

The mounting of the fuel tank consists of 6 parts which are needed to weld. The fixture used for the fuel tank mounting bracket has a rotating plate mounted on a plumbing block which helps to tilt the fixture by 45^{o}, which is mounted on a bearing housing which can rotate up to 180^{o} in horizontal direction. In this mounting the distance plays an important role, so the fixture has locator pins to locate the distance, if due to some technical issue the distance is not maintained an alarm gives the signal for the misalignment. Also, if there is any misalignment in the bracket the welding torch does not work. Thus, this fixture helps to maintain the quality and accuracy of the mounting bracket.

4. Types Of Welding Joints

Welding Joint is referred to as joining or fitting of metal surfaces in prior arrangement or configuration according to requirement. Application of welding joints can be endless because of its monopoly of use in the industry in today's era.

According to AWS (American Welding Society) types of welds are classified into 5 types:

1. Butt joint welding
2. Lap joint welding
3. Edge joint welding
4. Tee joint welding
5. Corner joint welding

4.1 Butt Joint Welding

Butt Joint Welding is a type of welding where two adjacent surfaces are joined together. Application of Butt welding is it is used in pipes, fabrication of structures, valve fittings, automotive parts etc.

Types of Butt Welding:

1. Square welding
2. Single bevel welding
3. Double bevel welding
4. V-groove welding
5. Double V-groove welding
6. U-groove welding
7. Double U-groove welding
8. J-welding welding
9. Double J-groove welding

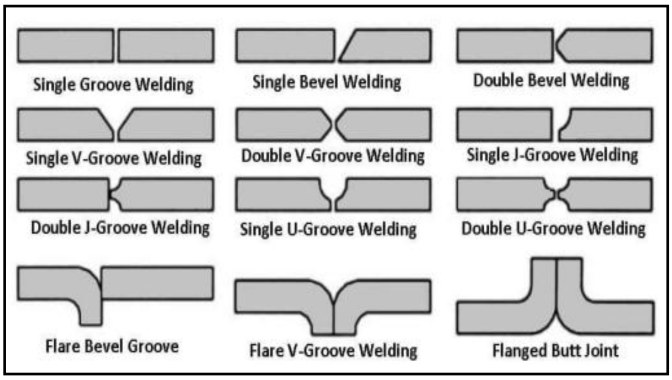

Fig. 1: - Butt Joint Welding

4.2 Lap Joint Welding

Lap Joint Welding is a type of welding where the overlapped metal surfaces are joined or fitted together. It is widely used in combined electron beam, laser beam, and resistance spot welding. Lap joints are often used on thick materials, and are used for sheet metal.

Some drawbacks of lap joint welding are lamellar tearing and corrosion due to the overlapping of fall metals. But you can easily handle them by applying the correct technique of modifying the variables

Following are the typical examples of lap joints.

1. Filet welding
2. Spot welding
3. Plug welding
4. Slot welding
5. Bevel groove welding
6. Flare bevel groove welding
7. J-groove welding

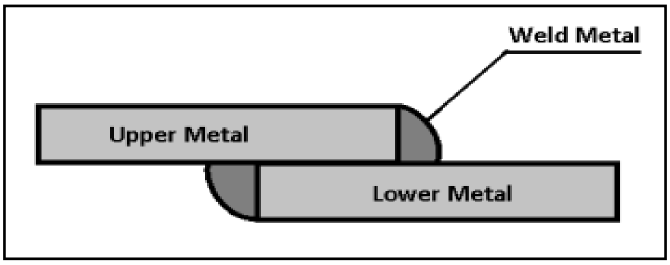

Fig. 2: - Lap Joint Welding Types

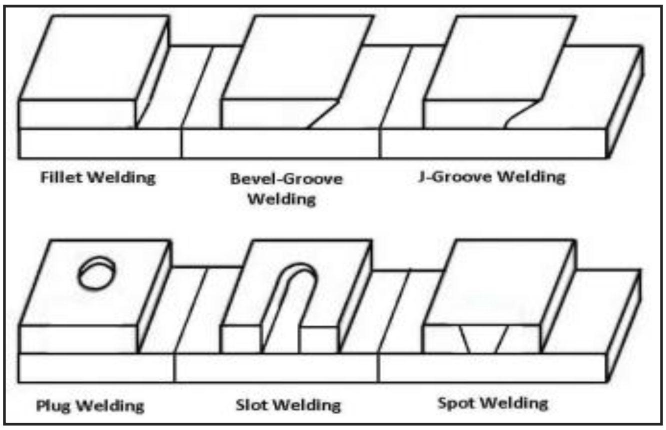

Fig. 3: - Lap Joint Welding

4.3 Edge Joint Welding

Similar to lap joint where the parallel surfaces are joined or fixed together at the point of welding. It is often used for joining the edges of sheet metal or mufflers. Used in areas like low pressure and stress. It is not a very strong joint. The defects in edge type welding are porosity, lack of fusion, lava inclusion, etc.

Types of Edge Joint Welding:

1. V-groove welding
2 .U-groove welding
3 .J-groove welding
4. Bevel groove welding
5. Square groove welding
6. Corner flange welding
7. Edge flange welding

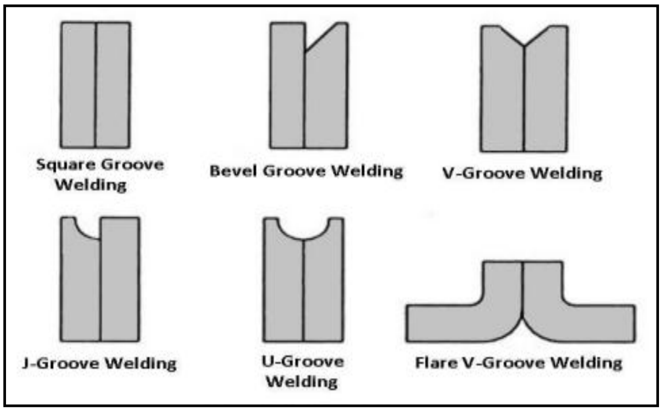

Fig. 4: - Edge Joint Welding

4.4 Tee Joint Welding

In Tee Joint Welding, when the two metal plates are at angle of 90° with one plate is lie on the center of the other plate like a "T" shape. It is known as tee joint welding. But, again we will have a drawback in the tee joint, which is lamellar tearing. .

Following are examples of tee joint welding.

1.Plug welding
2.Slot welding
3.Bevel groove welding
4.Flare bevel groove welding
5.Fillet welding
6.J-groove welding
7.Melt through welding

3.5 Corner Joint Welding

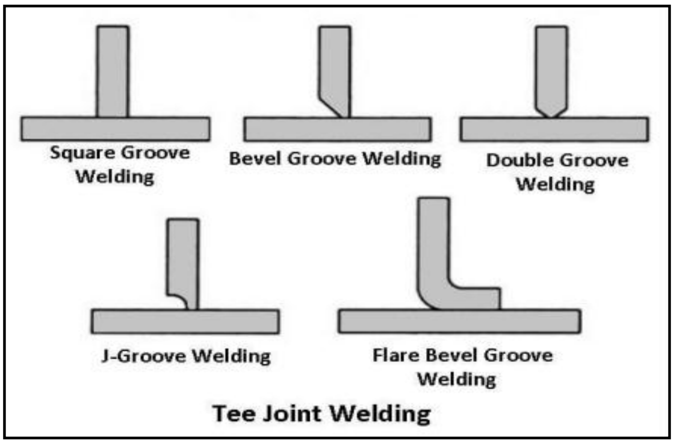

Fig. 5: - Tee joint welding

Similar to tee type welding joint, the difference is the positing of the metal surfaces in tee type the metals are placed in the middle while in corner joint welding the metal surface is placed at the corner end. Applications, of corner joint welding are there are used in joining sheet metal surfaces also used in manufacturing of boxes, frames, bars etc.

Types of Corner Joint Welding:

1. Fillet welding
2. Spot welding
3. Edge welding
4. J-groove welding
5. U-groove welding
6. V-groove welding
7. Flare V-groove welding
8. Square or butt groove welding
9. Corner flange welding
10. Bevel groove welding

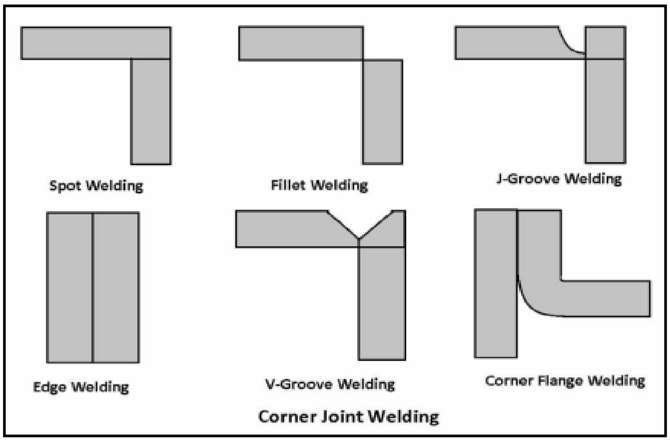

Fig. 6:- Corner Joint Welding

5. Defects in Welding

Welding defects (flaw) are the unwanted irregularities or discontinuities that are present in the welding product, which is not acceptable under the standardized rules and regulations. Which later lead to wear and failure of the weld and cause damage and loss to the entire product or environment in which it's been used.

According to American Society of Mechanical Engineers (ASME) weld defect or flaw are caused due to factors

1. 45% poor process conditions.
2. 23% operator error.
3. 12% wrong technique.
4. 10% incorrect consumable (filler material/rod).
5. 5% Bad weld channel.

5.1 Welding defects are classified as

A. External Welding Defects.

a. Cracking
b. Porosity
c. Undercut
d. Overlap
e. Spatter
B. Internal Welding Defects.

a. Slag inclusion
b. Lack of fusion
c. Incomplete penetration
d. Shrinkage cavities

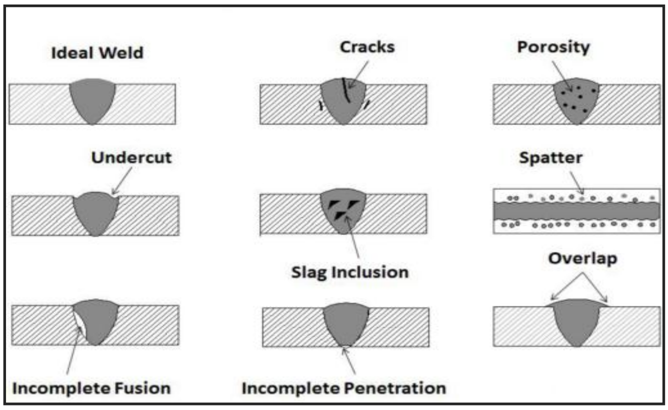

Fig. 7: - Welding Defects

Shielding gas also affects the quality and strength of the weld, we mostly use Carbon dioxide.

As it is 1.5 times heavier than air and has a high oxidizing potential. And it gives few defects.

6.Techniques to identify defects

6.1 Dye Penetration Test (DPT).

Dye penetration test is used to identify and locate the surface in all non-porous and non-magnetic materials.

In this method first we need make the surface clean and then apply color dye on the weld surface with the help of spraying or brushing, then the extra dye is removed and then we apply the developer which helps us to clearly notice the defects that are present on the weld.

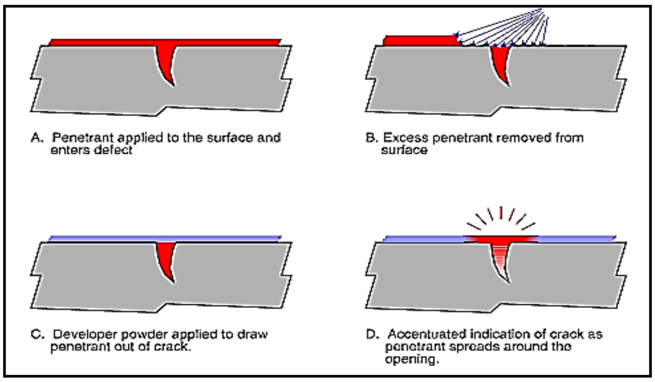

Fig. 8: - Dye penetration test

6.2 Magnetic particle inspection (MPI).

Magnetic particle inspection is a simple Non-destructive testing to find irregularities and weld flaws in magnetic materials.

In this method first, the specimen is passed through an electric current to get a magnetic field or we create it with the help of an external magnetic field. And the edge of the crack will be north and south poles now if present and we sprinkle iron particles that are attracted to the crack edges and we get to know the defects/flaws.

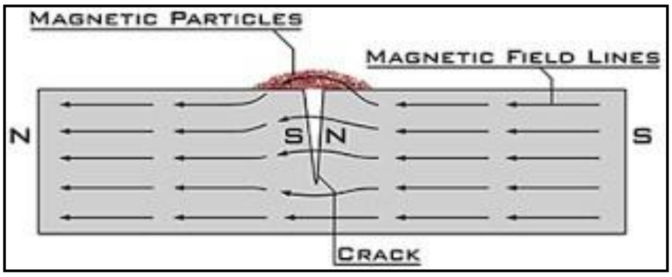

Fig. 9: - Magnetic particle inspection

6.3 Radiographic testing method (RT).

Radiographic testing method is Non-destructive testing used for the identification of internal defects or internal discontinuities in the weld.

This method is based on short wavelength electromagnetic radiation. Which is passed through material and we get a radiographic film on the screen.

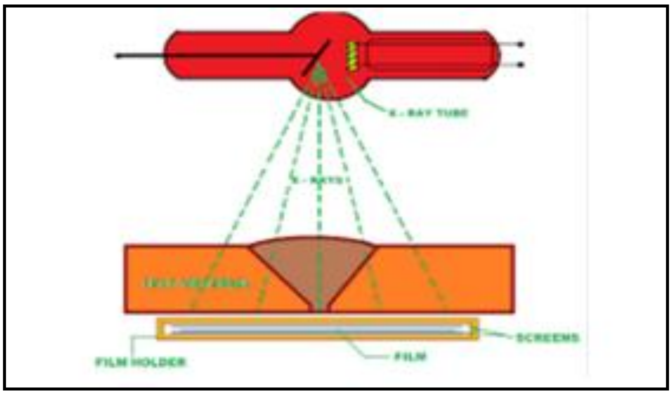

Fig. 10: - Dye penetration test

6.4 Ultrasonic Testing (UT).

Ultrasonic Testing method is Non-destructive testing used for the thickness of the material and flaw detection.

In this method first we pass the high frequency (0.5MHz to 20MHz) sound waves which travel through in different speeds in different materials. The sound wave signals are reflected back and then we get the results on the screen and can know about the flaws.

Fig. 11: -Ultrasonic Testing

6.5 Visual Inspection (VI)

Visual Inspection is a Non-destructive examination method mostly used for quality control, data analysis and checking the correctness visually. In this method the Inspector who is an experienced person of the field is there to take a closer look and find out the flaws and defects of the weld.

7. CO_2 Arc Welding

In CO2 arc welding, the filler welding wire is fed into the welding torch with the help of a motor. To protect the welding material from reacting with atmospheric oxygen and nitrogen, CO2 gas is supplied from the nozzle to shield the welding pool area.

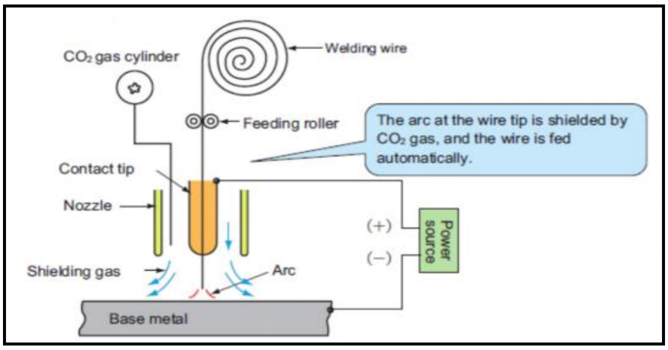

Fig. 12: - CO_2 Arc Welding

7.1 Principle of CO_2 Arc Welding

The welded material having blowholes is not a good thing or considered good. CO2 gas is decomposed by the high temperature arc heat into CO and O near the arc. Now O in FeO combines with Si and Mn and floats upon the surface of the weld pool.

$CO_2 \leftrightarrows CO + O$

$FeO + O \leftrightarrows FeO$

$FeO + C \leftrightarrows Fe + CO$

$FeO + Mn \rightleftarrows Fe + MnO$

$2FeO + Si \leftrightarrows 2Fe + SiO_2$

7.2 Molten Droplet Transfer: -

The process of melting a feeding wire and passing it to the base metal can be done in three different ways i.e. short-circuiting transfer, globule transfer and spray transfer.

7.3 Short Circuit Transfer

If a low welding current is used in CO2 arc welding or MIG welding, the droplets are transferred to the base metal after short-circuiting with it. It is suited for welding thin plates and in all-position welding such as vertical or overhead welding.

7.4 Globule Transfer

In high current CO2 arc welding, the mode of droplet transfer becomes globule transfer mode. In this, a slightly higher amount of spatter is emitted than in other modes. But it is used as it is highly efficient.

7.5 Spray Transfer

MIG welding uses DC electrode with inert gas shielding and positive polarity, which leads to formation of small droplets than the wire diameter due to the effect of plasma flow. This means the emission of spatter is little and the weld bead with a good appearance can be obtained.

8. Welding Conditions and Their Effects

8.1 When welding speed is increased

1. Penetration becomes less dip
2. Spatter increases
3. Undercut happens if speed is excessive
4. High welding reinforcement is required
5. Bead becomes less wide and narrower

8.2 Tip to Base Contact length is more

1. Staggered bead appearance
2. When feed rate is constant welding current decreases and the penetration decreases

8.3 Long Nozzle Standoff

1. As the gas shielding effect reduces the porosity increases

8.4 Short Nozzle Standoff

2. The splatter tends to block the nozzle and welding quality decreases
3. We can't see the line of welding as the nozzle is too close to the line

8.5 High Welding Current

1. More deep penetration than normal
2. Higher weld reinforcement
3. Wider bead width

8.6 Welding torch inclined for forward welding

1. Bead width increases
2. Less penetration

3. Higher reinforcement is required

8.7 Shielding Gas

1. When the flow rate is low or high winds are flowing porosity occurs
2. Its composition affects the properties of the weld

8.8 Base Metal Surface

1. Contaminants will damage the quality of the weld and cause porosity

9. Features of Forehand Welding

1. We can easily target the feeding wire on the welding line
2. Less reinforcement and flat bead shape is achieved
3. Consistent melting is achieved through the root pass bead
4. As molten metal flows ahead shallow penetration is achieved

10. Features of Backhand Welding

1. As welding nozzle hides the line to be welded, welding is a little difficult
2. High reinforcement and narrow bead shape is achieved
3. It is hard to obtain consistent melting through the root pass
4. As the molten pool is formed backwards deep penetration is achieved

11. Influence of wind velocity

X-ray tests have shown that there is a sharp increase of blowholes when the wind is over 2 m/sec. in velocity and the weld bead is deposited on a 9 mm thick plate.

12. Weld Imperfection and Preventive Measures

12.1 Pits or Blowholes

1. CO_2 gas flow shortage
2. The gas heater is not working properly
3. CO_2 gas is not pure enough
4. Gas shielding is not proper

12.2 Overlap

1. Welding current is too low
2. Welding current is too high
3. Too low arc voltage or welding speed
4. Welding wire is targeting the wrong position

12.3 Undercut

1. Welding current is too high
   1. Voltage is too high
   2. Welding speed is too high
   3. There is rough manipulation of the welding torch

12.4 Meandered Bead

1. There is a deviation in the center of the wire fees roller
2. The contact tip is loosened
3. Wire straightener is not adjusted properly

12.5 Inadequate Penetration

1. Welding current is too low
2. Arc voltage is too low or too high
3. Welding speed is too high
4. Welding wire is targeted in a wrong position

13. Conclusion

Thus, we have overviewed Welding Fixtures, Welding Joints, Welding Defects and CO_2 arc welding. also analyzed about the parameters and properties affect welding of joints and welding defects.

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