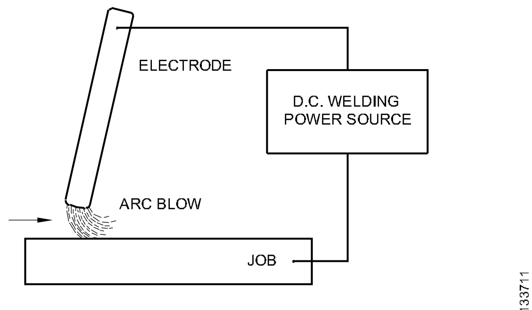
Arc blow its causes and remedial measures

Objectives : At the end of this lesson you shall be able to
- **explain the arc blow in DC welding**
- **explain the effects of arc blow on welds**
- **describe the various methods used to control the arc blow.**

Arc blow in dc welding: When the arc deviates from its regular path due to the magnetic disturbances it is called ‘Arc blow’. (Fig 1)

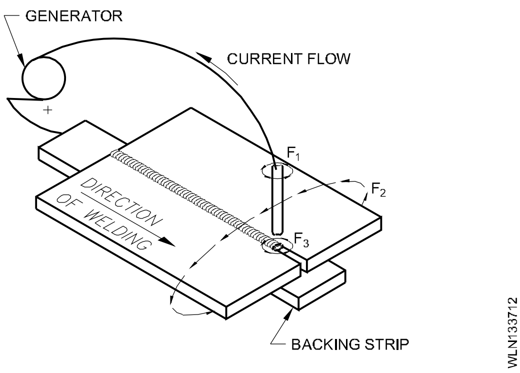
Fig 1



ARC BLOW IN DC ARC WELDING

Causes and effects of arc blow: Whenever a current flows in the electrode a magnetic field is formed around the electrode and the arc F_1 and F_3 (Fig 2). Likewise a similar magnetic field is also formed around the base metal F_2 (Fig 2). Due to the interaction of these two magnetic fields, the arc is blown to one side of the joint. At the starting of the weld there will be forward blow and at the end backward blow. (Fig 3)

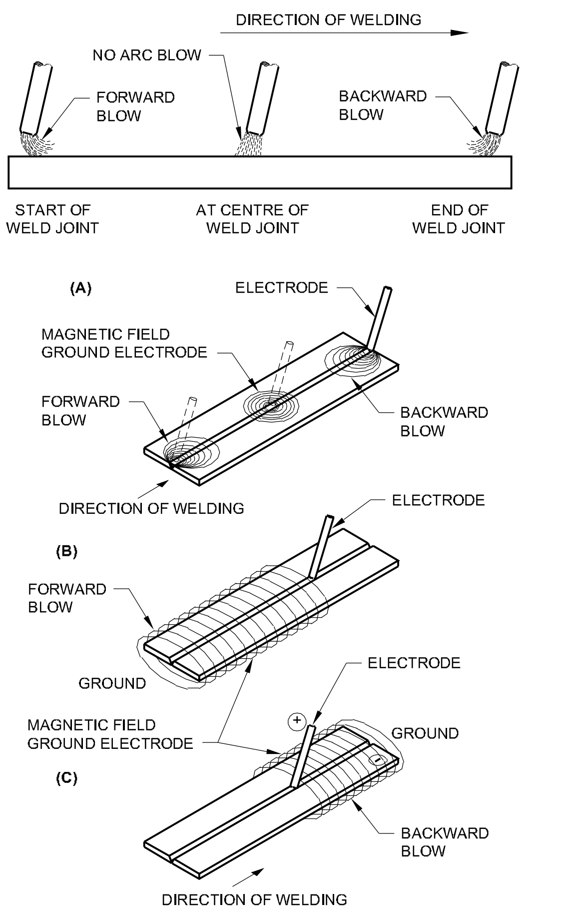
Fig 2



Due to this the following effects occur.

- more spatters with less deposition of weld metal.
- poor fusion/penetration.
- weak welds.
- Difficulty in depositing weld metal at the required place in the joint.
- The bead appearance will be poor and slag inclusion defect will also take place.

Fig 3



MAGNETIC FIELDS THAT RESULT IN FORWARD OR BACKWARD ARC BLOW (A) AROUND THE ELECTRODE/ARC (B) AND (C) AROUND THE WORK

Methods used to control the arc blow

The arc blow can be controlled by:

- Place the earth connection as far from the weld joint as possible. (Fig 4)
- changing the position of the earth connection on the work.
- Changing the position of the work on the welding table.
- wrapping the electrode cable around the work. (Fig 5)
- welding towards a heavy welding tack or a weld already made.

Fig 4

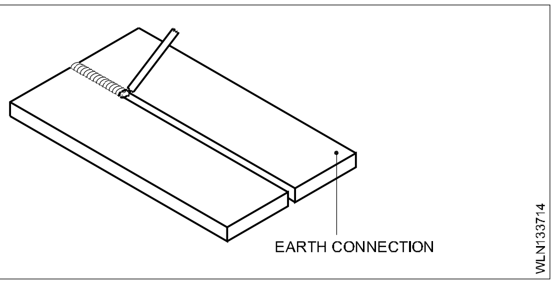
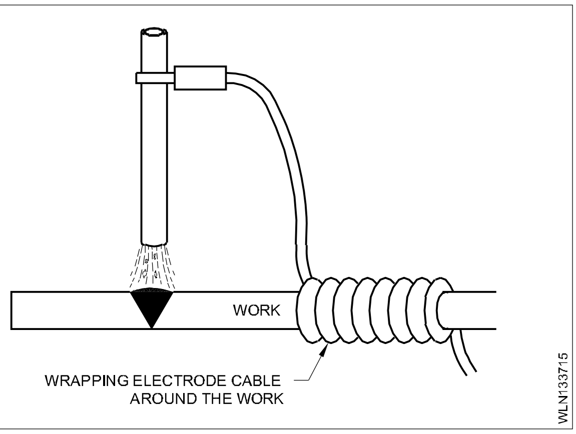


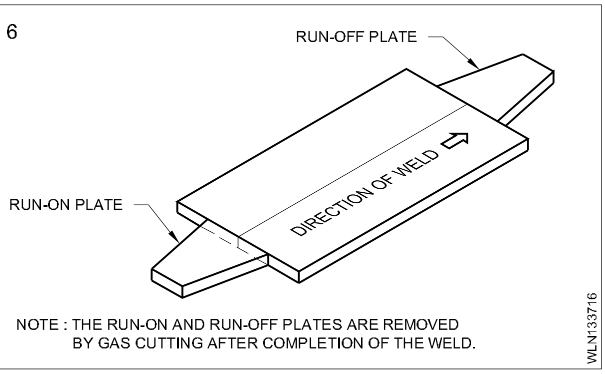
Fig 5



- keeping a magnetic bridge on the top of the groove joint.
- holding the correct electrode angle with a short arc. use ‘run on’ and ‘run off plates. (Fig 6)

If all the above methods fail to control the ‘arc blow’, change to AC supply.

Fig 6

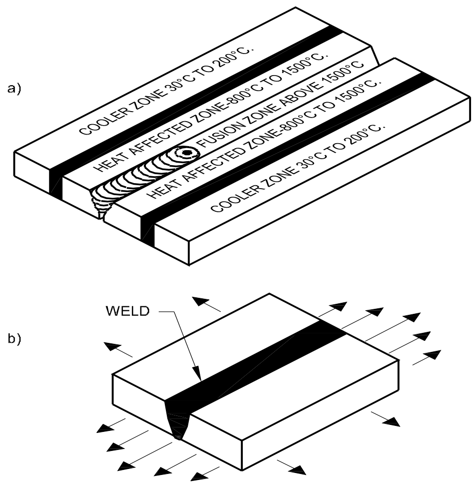


Distortion and its control

Objectives : At the end of this lesson you shall be able to
- **explain the causes of distortion**
- **describe the types of distortion**
- **explain the methods of preventing distortion**
- **explain the methods of correcting distortion.**

Causes of distortion: In arc welding, the temperature at different areas of the joint are different. (Fig 1a). The expansions in these areas are also different depending on the temperature (Fig 1b). In the same way after welding, different areas of the joint contract differently, But in a solid body (i.e., the parent metal) it cannot expand or contract differently at different areas. This uneven expansion and contraction of the welded joint due to uneven heating and cooling in welding creates stresses in the joint. These stresses make the welded job to change its size and shape permanently (i.e. deformation) and this is called distortion of the welded joint. (Fig 2)

Fig 1



EXPANSION OF A PLATE DURING WELDING (MILD STEEL)

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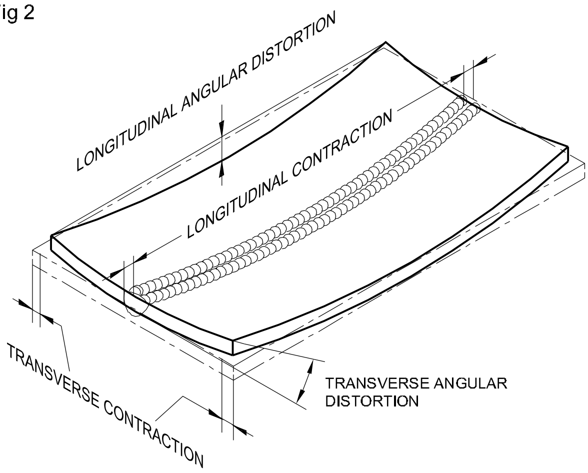
Fig 2



DISTORTION IN SINGLE-SIDED WELDING OF AN UNRESTRAINED BUTT JOINT WITH SEVERAL SMALL RUNS

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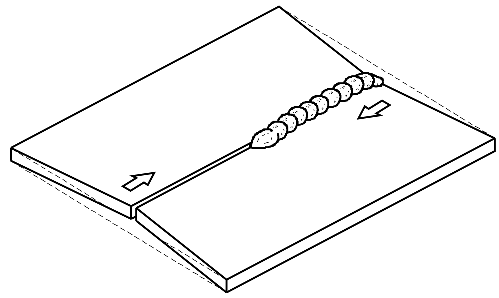
Types of distortion

The 3 types of distortion are:

- longitudinal distortion
- transverse distortion
- angular distortion.

The figures (3,4,5) illustrate the different types of distortion.

Fig 3



LONGITUDINAL DISTORTION

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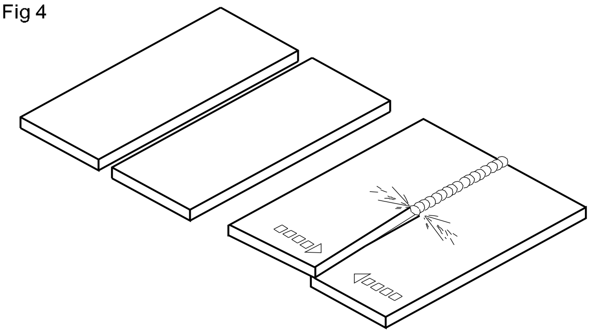
Fig 4



TRANSVERSE DISTORTION

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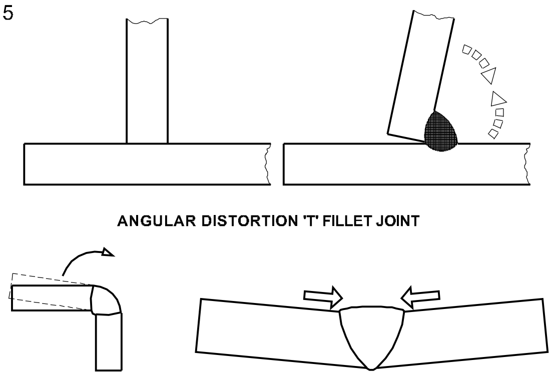
Fig 5



ANGULAR DISTORTION 'T' FILLET JOINT

OUTSIDE CORNER JOINT SINGLE 'V' BUTT JOINT

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Factors affecting distortion

Design

Parent metal

Joint preparation and set up

Assembly procedure

Welding process

Deposition technique

Welding sequence

Unbalanced heating about the neutral axis

Restraint imposed

Either one or more of these above factors are responsible for distortion, in a welded job. To avoid or reduce the distortion in a welding job these factors are to be taken care of-before, during and after welding. The methods adopted to avoid or reduce distortion are as follows.

Prevention of distortion: The following methods are used to prevent and control distortion.

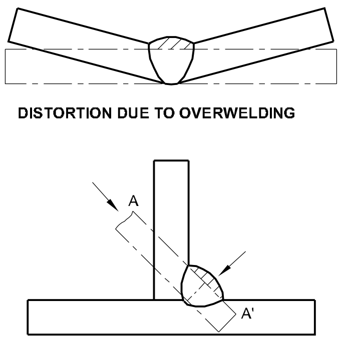
- Reducing the effective shrinkage force.
- Making the shrinkage forces to reduce distortion.
- Balancing the shrinkage force with another shrinkage force.

Methods of reducing the effective shrinkage forces

Avoiding over-welding/Excessive reinforcement: Excessive build up in the case of butt welds and fillet welds should be avoided. (Fig 6)

The permissible value of reinforcement in groove and fillet welds is T/10 where "T" is thickness of parent metal.

Fig 6



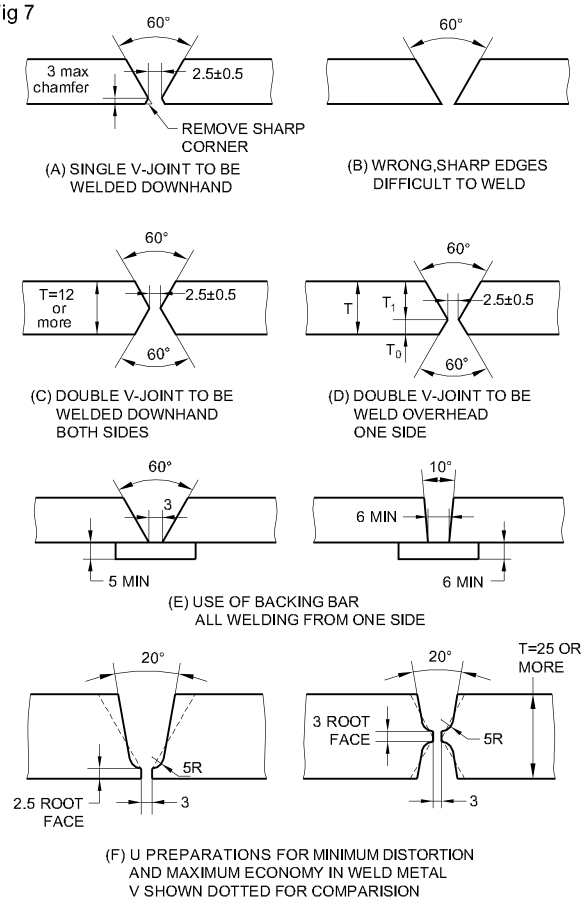
DISTORTION DUE TO OVERWELDING

EXCESS WELD METAL ABOVE THE LINE A A' OF CONVENTIONAL FILLET WELD

Use of proper edge preparation and fit up: It is possible to reduce the effective shrinkage force by correct edge preparation. This will ensure proper fusion at the root of the weld with a minimum of weld metal. (Fig 7)

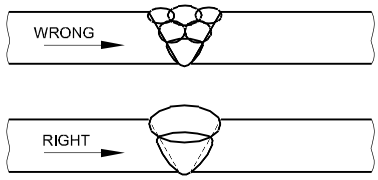
Use of few passes: Use of fewer passes with large dia. electrodes reduces distortion in the lateral direction. (Fig8)

Fig 7



PREPARATION OF PLATES FOR BUTT WELDING

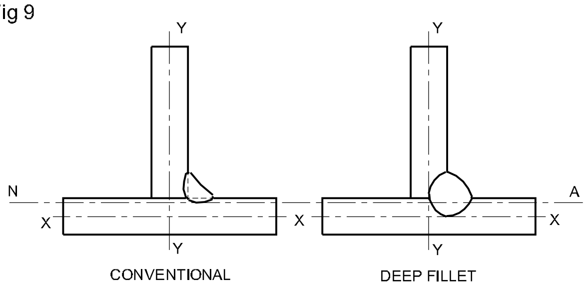
Fig 8



COMPARISION OF PASSES OF WELD

use of deep fillet weld: Place the weld as possible to the neutral axis by using the deep fillet method. This will reduce the leverage of pulling the plates out of alignment. (Fig 9)

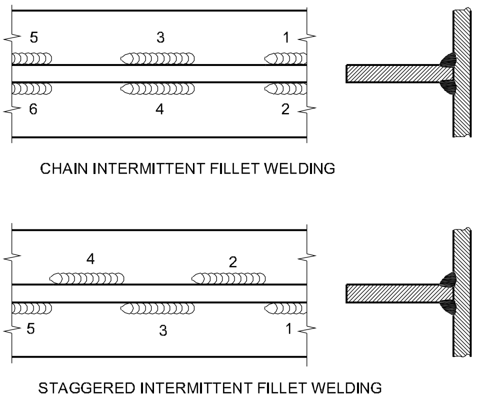
Fig 9



DEEP PENETRATION FILLET WELD

Use of intermittent welds: Minimize the amount of weld metal with the help of intermittent welds instead of continuous welds. This can be used with fillet welds only. (Fig 10)

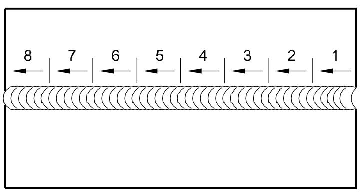
Fig 10



INTERMITTENT WELDING

Use of 'back step' welding method: The general direction of welding progression is from left to right. But in this method each short bead is deposited from right to left. In this method. the plates expand to a lesser degree with each bead because of the locking effect of each weld. (Fig 11)

Fig 11

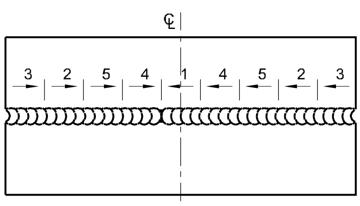


BACK STEP WELDING METHOD

Welding from center: Welding of long joints from center outwards breaks up the progressive effect of high stresses on continuous weld.

Use of planned wandering method: In this method welding starts at the center, and thereafter portions are completed on each side of the center in turn. (Fig 12)

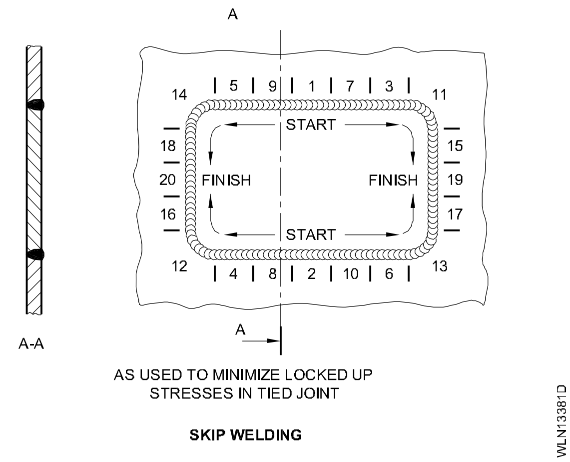
Fig 12



PLANNED WANDERING METHOD

Use of skip welding: In this method, the weld is made not longer than 75 mm at one time. Skip welding reduces locked up stresses and warping due to more uniform distribution of heat. (Fig 13)

Fig 13

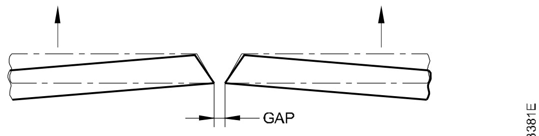


SKIP WELDING

Methods used for making the shrinkage forces work to reduce distortion

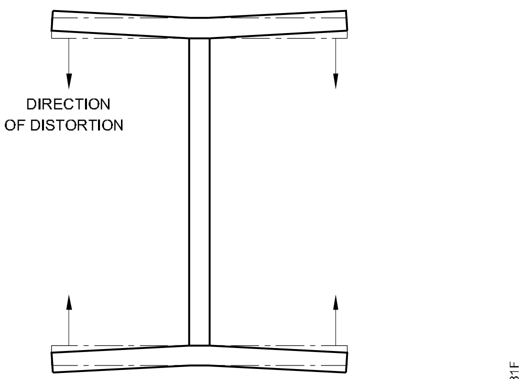
Locating parts out of position: Distortion may be allowed for by pre-setting the plates in the opposite way so that the weld pulls them to the desired shape. When the weld shrinks it will pull the plate to its correct position (Fig 14 & 15)

Fig 14



PRE-SETTING TO COMPENSATE FOR ANGULAR DISTORTION

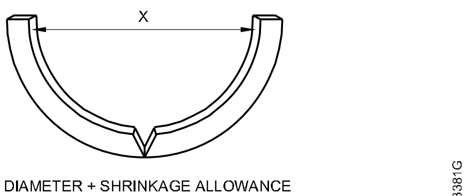
Fig 15



PRE-CAMBERING TO COMPENSATE FOR ANGULAR DISTORTION

Spacing of parts to allow for shrinkage: Correct spacing of the parts prior to welding is necessary. This will allow the parts to be pulled in correct position by the shrinkage force of the welding. (Fig 16)

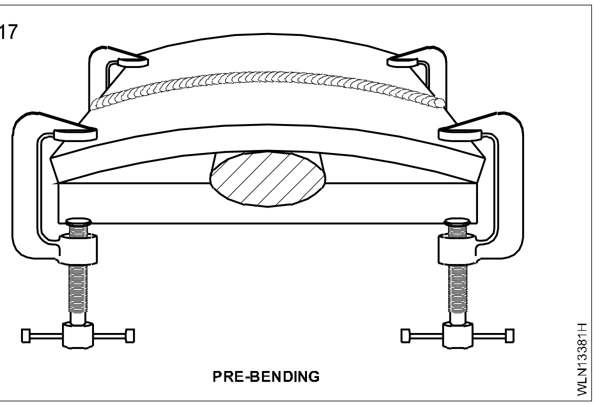
Fig 16



SPACING OF PARTS TO ALLOW FOR SHRINKAGE

Pre-bending: Shrinkage forces may be put to work in many cases by pre-bending. (Fig 17)

Fig 17

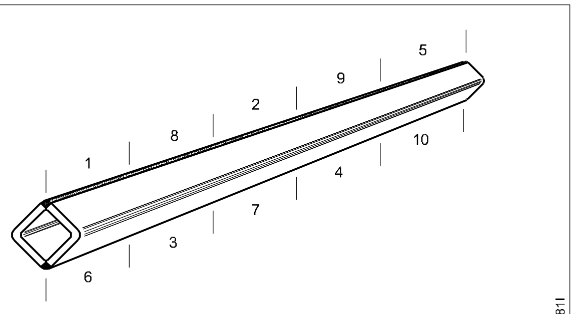


PRE-BENDING

Methods of balancing of one shrinkage force with another shrinkage force

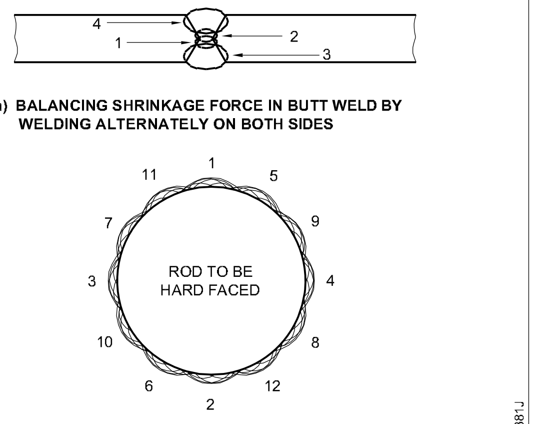
Use of proper welding sequence: This places the weld metal at different points about the structure. In this method, welds are made from each side alternately so that when a second run of weld metal shrinks it will counteract the shrinkage forces of the first weld. (Figs 18, 19 a and 19b)

Fig 18



AS USED WHEN FABRICATING SQUARE SECTIONS FROM ANGLES OR CHANNELS

Fig 19

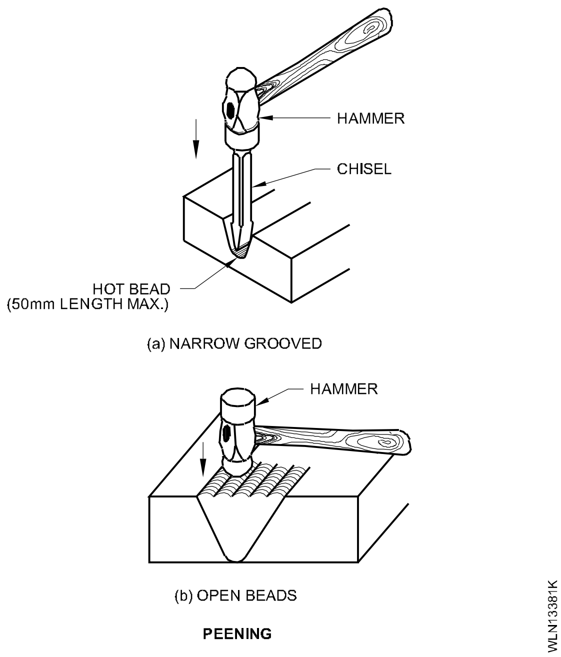


a) BALANCING SHRINKAGE FORCE IN BUTT WELD BY WELDING ALTERNATELY ON BOTH SIDES

b) SEQUENCE WELDING USED TO CONTROL DISTORTION IN HARD FACING OPERATION

Peening: This is light hammering of the weld metal immediately after it is deposited. By peening the bead, it is actually stretched counteracting its tendency to contract as it cools. Fig 20.

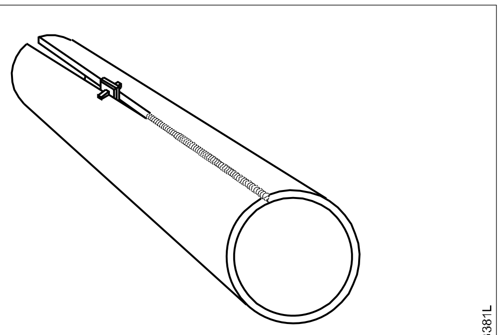
Fig 20



PEENING

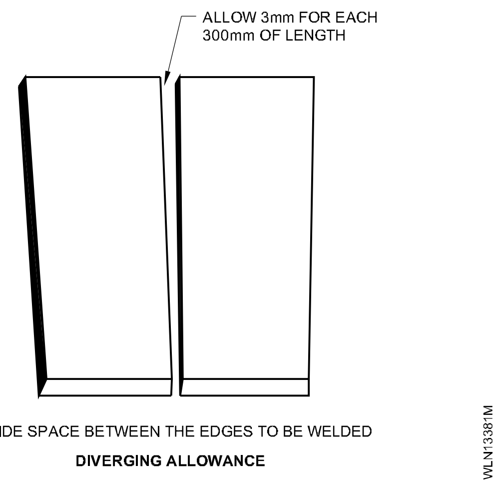
Divergence allowance: As there is a tendency of the plates to extend & converge along the seam during welding, this technique is used to diverge the plates from the point where welding commences by placing a wedge or an alignment clamp between the plates ahead of the weld. (Fig 21& 22)

Fig 21



DIVERGENCE ALLOWANCE

Fig 22



PROVIDE SPACE BETWEEN THE EDGES TO BE WELDED

DIVERGING ALLOWANCE

The spacing allowances are as follows.

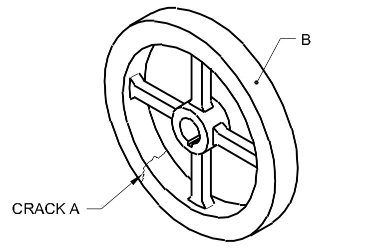
3mm/m for (mild steel) Ferrous metals

10 mm/m for non ferrous metals

While cooling, the shrinkage stresses will pull the plate in correct alignment.

Preheating: Some metals would normally fracture if welded in the cold state. They may be welded successfully by preheating and subsequent controlled cooling. (Fig 23)

Fig 23



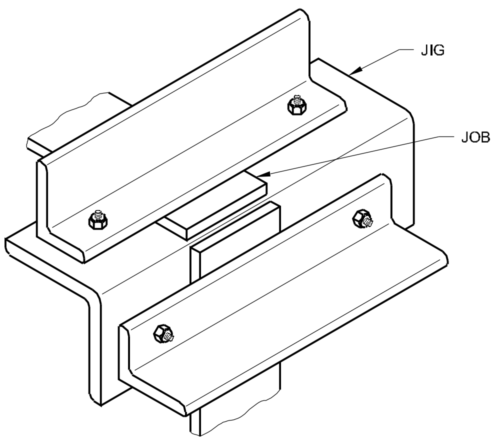
IF THE FRACTURE IN THE WHEEL AT 'A' IS TO BE REPAIRED. THE PREHEATING FLAME SHOULD BE APPLIED AT 'B' TO AVOID CRACKING.

TECHNIQUE OF LOCAL PREHEATING

WLN13381N

Jigs and fixtures: Jigs and fixtures are used to hold the work in a right position during welding. By using them the shrinkage forces of the weld are balanced with sufficient counter force of the jigs and fixtures. (Fig 24)

Fig 24



USE OF JIGS AND FIXTURES TO AVOID DISTORTION

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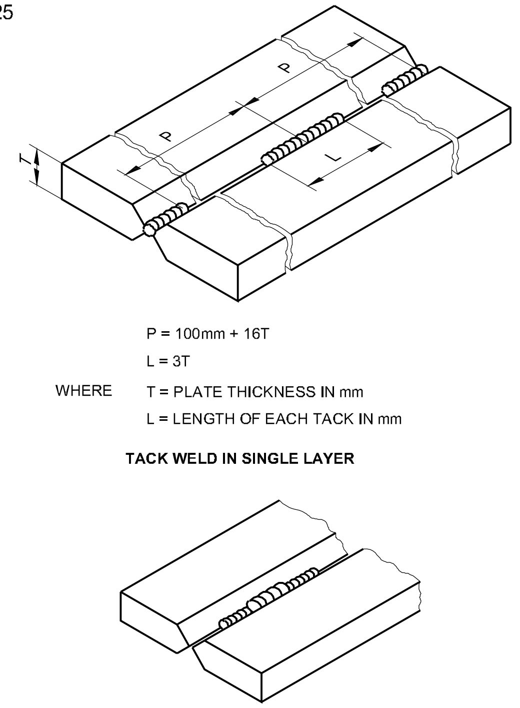
Tack-welding: A tack weld is a short weld made prior to welding to hold the plates in perfect alignment and with uniform root gap. Tack welds are made at regular intervals along the joint with high current to obtain proper penetration. (Fig 25) They are necessary where the plates cannot be held by a fixture. (Fig 26)

Methods of correcting distortion: Distortion may take place even after following a planned procedure as it is difficult to control distortion to the full extent. So some mechanical means and application of heat are used to remove distortion after it occurs.

Mechanical methods: Small parts, deformed by angular distortion can be straightened by using a press. If the parts of the assembly are not restrained, they can be brought into alignment by hammering, drifting or jacking without giving excessive force (stress}.

Fig 25



P = 100mm + 16T

L = 3T

WHERE T = PLATE THICKNESS IN mm

L = LENGTH OF EACH TACK IN mm

TACK WELD IN SINGLE LAYER

TACK WELD IN TWO LAYERS.
TOP WELD IS SHORTER IN LENGTH THAN BOTTOM LAYER.

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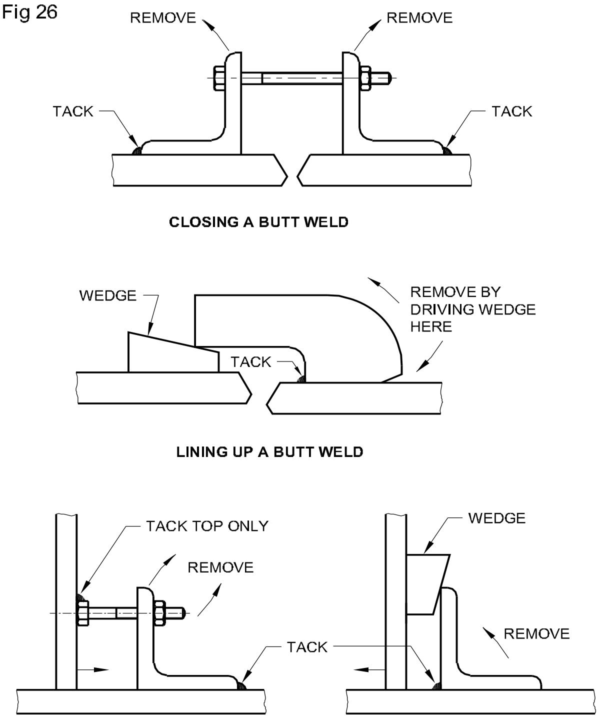
Fig 26



TACK WELDING ERECTION CLEATS AND AIDS TO ASSEMBLY

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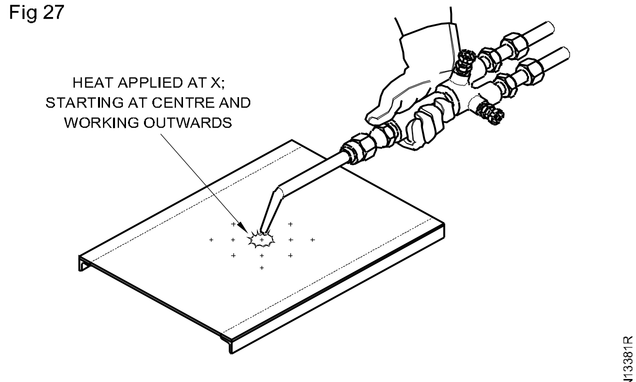
Heating methods: The distorted part is heated locally and rapidly keeping the surrounding metal reasonably cool.

Heat small areas at a time. It should not exceed bright red hot condition.

If thin plates are buckled they can be corrected by local spot heating on the convex side. Starting at the center of the buckled area heat symmetrically outwards as shown in Fig 27.

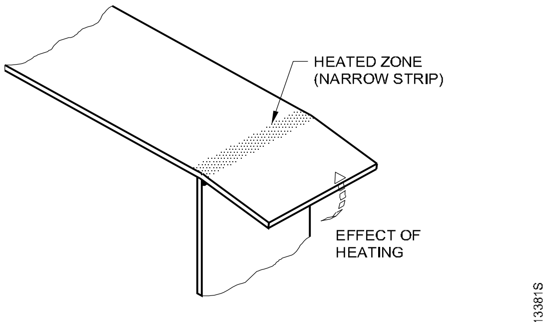
Fig 27



SPOT HEATING TO CORRECT BUCKLING OF THIN SHEET

Correction of distortion caused by fillet welds is done by local heating on the underside of the plate in a narrow strip following the line of the joint. (Fig 28)

Fig 28



CORRECTION OF DISTORTION CAUSED BY FILLET WELD

Straightening by flame heating: The most common distortion-removal technique is to use a flame and heat the part at selected spots or along certain lines and then to aircool it. The area to be straightened is heated to between 600 and 650°C for plain carbon and low alloy steels and suddenly cooled in air, or if necessary with a spray of water in low carbon steels.

The methods of flame straightening are shown in Fig 29.

In Line heating (Fig 29a) heat from the torch is applied along a line or a set of parallel lines. This method is frequently used for removing the angular distortion produced by the fillet welds attaching a plate to its stiffener.

In pipe-needle (Fig 29b) heating, heat is applied along two short lines crossing each other. This method is half way between line heating and spot heating. Since the shrinkage and angular distortion occur in two directions, this method produces a uniform distortion-removal effect.

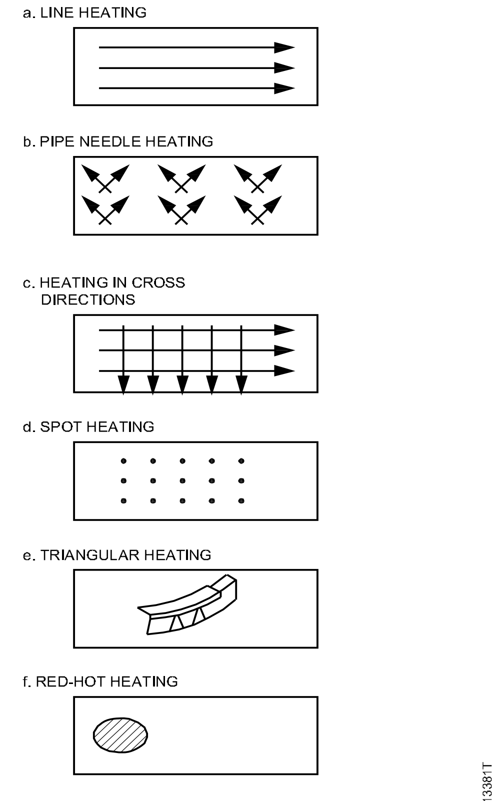
In checker board (cross-directions) heating, (Fig 29c) heat is applied along a pair of two lines crossing each other. This method is used to remove severe distortion.

In spot heating. (Fig 29e) heat is applied on a wedge shaped area, and this method is useful for the removal of bending distortion in frames.

In triangular heating (Fig 29e) heat is applied on a wedge shaped area, and this method is useful for the removal of bending distortion in frames.

Red hot heating (Fig 29f) is used when severe distortion has occurred in a localised area, and it may be necessary to heat the area to a high temperature and beat it with a hammer. This method can cause metallurgical changes.

Fig 29



METHODS OF FLAME-STRAIGHTENING

Thermal treatments: To reduce distortion, various thermal treatments are done. They include preheat and post weld thermal treatments.

Preheating: Weld shrinkage is generally reduced by preheating. Actual measurements across welds during cooling have shown that less than 30% total contraction occurred in joints preheated to 200°C, compared to non-preheating joints.

Stress relief: In many cases thermal stress relief is necessary to prevent further distortion being developed before the weldment is brought to its finished state. Residual tensile stress in welds are always balanced by compressive residual stresses. If a considerable portion of the stressed material is machined out, a new balance of residual stress will result, causing new distortion. Weld stress-relieving prior to machining is thus very important for prolonged dimensional accuracy of sliding and rotating parts.

Vibration stress relieving: This technique reduces distortion by means of vibrating the weldments. The equipment consists of a variable speed vibrator, which is clamped to the work piece, and an electronic amplifier, by varying the speed of the vibrating motor, the frequency can be varied until a resonant frequency has been reached for the work piece. The piece is then allowed to vibrate for a period which varies in relation to the weight of the work piece. Usually it ranges from 10 to 30 minutes. 30 to even 50% of the residual stresses are relieved using vibrating methods. The component thus balances roughly its residual stresses, and it remains undistorted.

Defects in arc welding - its effect

Objectives: At the end of this lesson you shall be able to
- **name different weld defects in arc welded joints**
- **define weld defect**
- **state the effect of defects on the welded joints**
- **differentiate between external and internal defects.**

Introduction: The strength of a welded joint should be more than or equal to the strength of the base metal. If any weld defect is in a welded joint, then the joint becomes weaker than the base metal. This is not acceptable.

So a strong or good weld should have uniformly rippled surface, even contour, bead width, good penetration and should not have defect.

Definition of a weld defect/fault: A defect or fault is one which does not allow the finished joint to withstand or carry the required load.

Effects of weld defect/fault: Always a defective welded joint will have the following bad effects.

– The effective thickness of the base metal is reduced.
– The strength of the weld is reduced
– The effective throat thickness is reduced
– The joint will break, when loaded, causing accident.
– The properties of base metal will change.
– More electrodes are required which will also increase the cost of welding.
– Waste of labour and materials.
– The weld appearance will be poor.

Since the weld defects will give bad effects on the joint, always proper care and action has to be taken before and during welding to avoid/prevent the defects. If the defects have already taken place then proper action has to be taken to correct/rectify the defect after welding.

The action/measure taken to avoid/prevent and correct/rectify a weld defect is also called as a remedy.

So some remedies may help to avoid/prevent a weld defect and some remedies may help to correct/rectify a weld defect which has already taken place.

Weld defect may be considered under two heads.

– External defects
– Internal defects

The defects which can be seen with bare eyes or with a lens on the top of the weld bed, or on the base metal surface or on the root side of the joint are called external defects.

Those defects, which are hidden inside the weld bead or inside the base metal surface and which cannot be seen with bare eyes or lens are called internal defects.

Some of the weld defects are external defects, some are internal defects and some defects like crack, blow hole and porosity, slag inclusion, lack of root penetration in fillet joints, etc. will occur both as external and internal defects.

External defects

1 Undercut
2 Cracks
3 Blow hole and porosity
4 Slag inclusions
5 Edge plate melted off
6 Excessive convexity/Oversized weld/Excessive reinforcement
7 Excessive concavity/insufficient throat thickness/ insufficient fill
8 Incomplete root penetration/lack of penetration
9 Excessive root penetration
10 Overlap
11 Mismatch
12 Uneven/irregular bead appearance
13 Spatters

Internal defects

1 Cracks
2 Blow hole and porosity
3 Slag inclusions
4 Lack of fusion
5 Lack of root penetration
6 Internal stresses or locked-up stresses or restrained joint.

Defects in arc Welding - Definition, Causes and Remedies

Objectives: At the end of this lesson you shall be able to
- **define common weld defects in arc welded joints**
- **describe the causes, remedies and corrections of weld defects.**

A sound or good weld will have uniformly rippled surface, even contour, bead width, good penetration and no defects.

Definition of a defect: A defect is one which does not allow the finished joint to withstand the required strength (load).

Causes for weld defects means wrong actions taken which creates the defect.

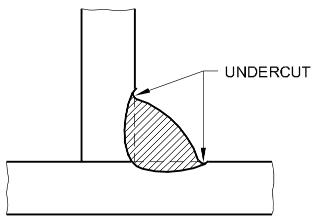
A remedy can be

a Preventing the defect by taking proper actions before and during welding.

b Taking some corrective actions after welding to rectify a defect which has already taken place.

Undercut: A grooved or channel formed in the parent metal at the toe of the weld. (Figs 1, 2 & 3)

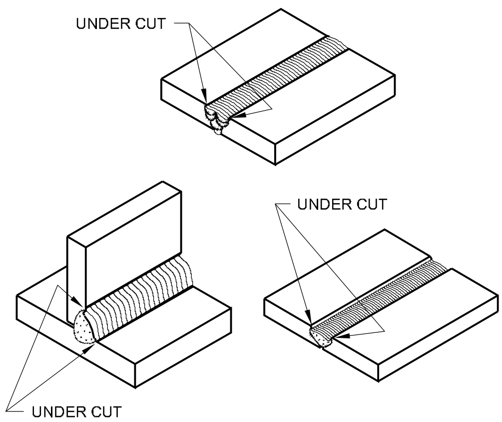
Fig 1



TEE-JOINT FILLET WELD

WLN133911

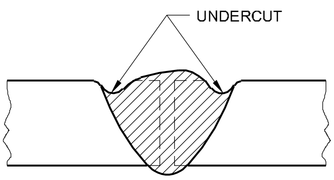
Fig 2



A SCHEMATIC DIAGRAM OF UNDERCUTS IN FILLET AND BUTT WELDS.

WLN133912

Fig 3



SQUARE-BUTT WELD

WLN133913

Causes

– Current too high

– Use of a very short arc length

– Welding speed too fast

– Overheating of job due continuous welding

– Faulty electrode manipulation

– Wrong electrode angle

Remedies

a Preventive action

Ensure

– proper current is set

– correct welding speed is used

– correct arc length is used

– correct manipulation of electrode is followed

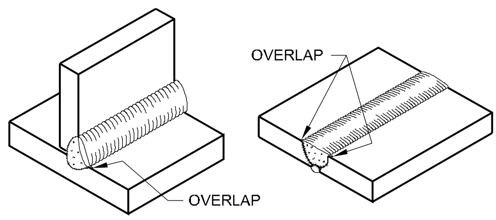
b Corrective action

– deposit a thin stringer bead at the top of the weld using a 2mm ø electrode to fill up the undercut.

Overlap

An overlap occurs when the molten metal from the electrode flows over the parent metal surface without fusing into it. (Fig 4)

Fig 4



SCHEMATIC DIAGRAM OF OVERLAP IN FILLET AND BUTT WELDS

WLN133914

Causes

– Low current.

– Slow arc travel speed.

– Long arc.

– Too large a diameter electrode.

– Use of wrist movement for electrode weaving instead of arm movement.

Remedies

a Preventive actions

– Correct current setting.

– Correct arc travel speed.

– Correct arc length.

– Correct diameter electrode as per metal thickness.

– Proper manipulation of electrode.

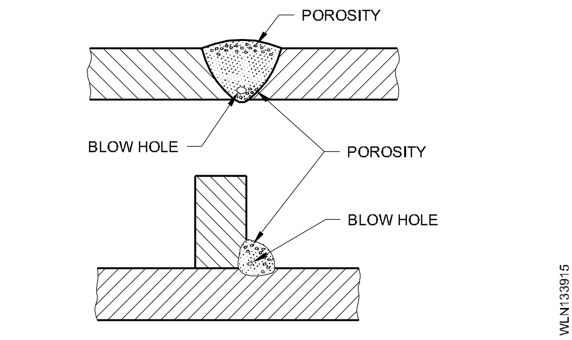
b Corrective actions

– Remove the overlap by grinding without an undercut.

Blowhole and porosity

Blow hole or gas pocket is a large diameter hole inside a bead or on the surface of the weld caused by gas entrapment. Porosity is a group of fine holes on the surface of the weld caused by gas entrapment. (Fig 5)

Fig 5



Causes

Presence of contaminants/impurities on the job surface or on electrode flux, presence of high sulphur in the job or electrode materials. Trapped moisture between joining surfaces. Fast freezing of weld metal. Improper cleaning of the edges.

Remedies

a Preventive actions

– Remove oil, grease, rust, paint, moisture, etc. from the surface. Use fresh and dried electrodes. Use good flux-coated electrodes. Avoid long arcs.

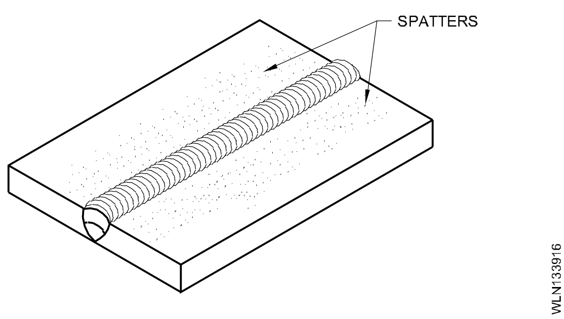
b Corrective action

– If the blowhole or porosity is inside the weld then gouge the area and re-weld. If it is on the surface then grind it and re-weld.

Spatter

Small metal particles which are thrown out of the arc during welding along the weld and adhering to the base metal surface. (Fig 6)

Fig 6



Causes

Welding current too high. Wrong polarity (in DC). Use of long arc. Arc blow. Uneven flux coated electrode.

Remedies

a Preventive actions

– Use correct current.

– Use correct polarity (DC).

– Use correct arc length.

– Use good flux-coated electrode.

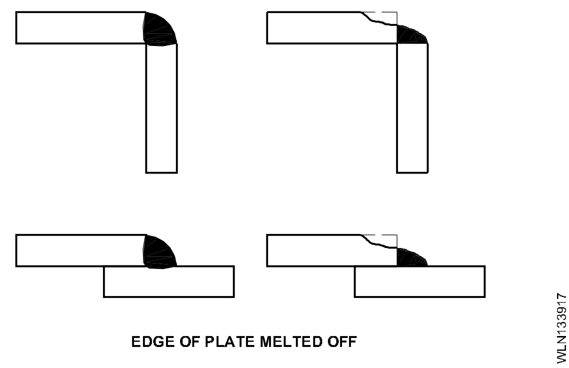
b Corrective actions

– Remove the spatters using a chipping hammer and wire brush.

Edge of plate melted off

Edge of plate melted off defect takes place in lap and corner joints only. If there is excess melting of one of the plate edges resulting in insufficient throat thickness then it is called edge of plate melted off defect. (Fig 7)

Fig 7



Causes

– Use of oversize electrode.

– Use of excessive current.

– Wrong manipulation of the electrode i.e. excessive weaving of electrode.

Remedies

a Preventive action

– Select correct size electrode.

– Set correct current.

– Ensure correct manipulation of electrode.

b Corrective action

– Deposit additional weld metal to increase throat thickness.

Crack

A hairline separation exhibits in the root or middle or surface and inside of the weld metal or parent metal. (Fig 8)

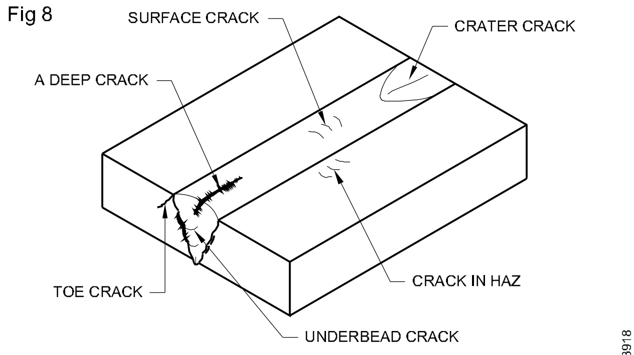


Fig 8

DIFFERENT TYPES OF CRACKS

Causes

- Wrong selection of electrode.
- Presence of localized stress.
- A restrained joint.
- Fast cooling.
- Improper welding techniques/sequence.
- Poor ductility.
- Absence of preheating and post-heating of the joint.
- Excessive sulphur in base metal.

Remedies

a Preventive actions

- Preheating and post-heating to be done on copper, cast iron, medium and high carbon steels.
- Select low hydrogen electrode.
- Cool slowly.
- Use fewer passes.
- Use proper welding technique/sequence.

Cracks

b Corrective actions

- For all external cracks to a smaller depth, take a V groove using a diamond point chisel upto the depth of the crack and re-weld (with preheating if necessary) using low hydrogen electrode. Cool the job slowly.
- For internal/hidden cracks gouge upto the depth of the cracks and re-weld (with preheating if necessary) using low hydrogen electrode. Cool the job slowly.

Incomplete penetration

Failure of weld metal to reach and fuse the root of the joint. (Fig 9)

Causes

- Edge preparation too narrow - less bevel angle.
- Welding speed too much.

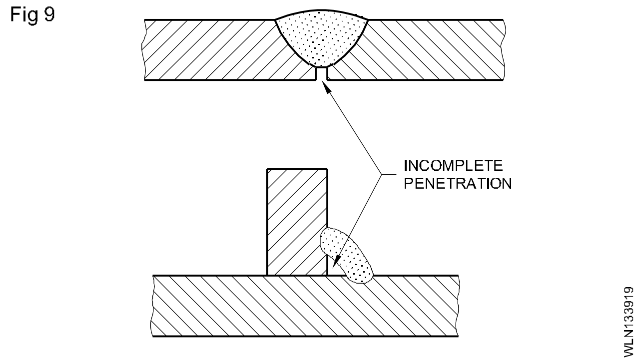


Fig 9

- Key-hole not maintained during welding the root run of a grooved joint.
- Less current.
- Use of larger dia. electrode.
- Inadequate cleaning or gouging before depositing sealing run.
- Wrong angle of electrode.
- Insufficient root gap.

Remedies

a Preventive actions

- Correct edge preparation is required.
- Ensure correct angle of bevel and required root gap.
- Use correct size of electrode.
- Correct welding speed is required.
- Maintain a keyhole throughout the root run.
- Correct current setting is required.

b Corrective actions

- For butt welds and open corner welds gouge the root of the joint and deposit the root run from the bottom side of the joint. For a Tee & lap fillet welds blow off the full weld deposit and reweld the joint.

Slag inclusion: Slag or other non-metallic foreign materials entrapped in a weld. (Fig 10)

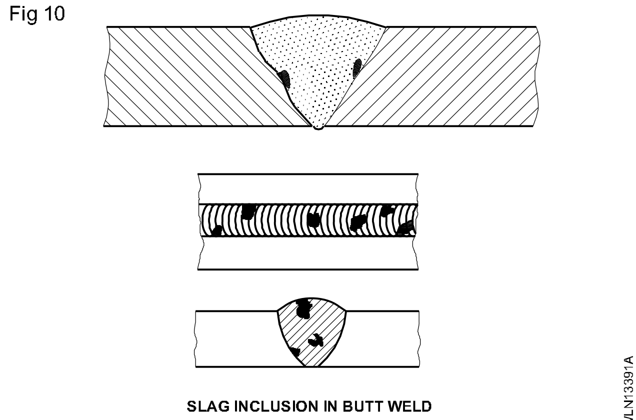


Fig 10

SLAG INCLUSION IN BUTT WELD

Causes

- Incorrect edge preparation.
- Use of damaged flux coated electrode due to long storage.
- Excessive current.
- Long arc length.
- Improper welding technique.
- Inadequate cleaning of each run in multi-run welding.

Remedies

a Preventive actions

- Use correct joint preparation.
- Use correct type of flux coated electrode.
- Use correct arc length.
- Use correct welding technique.
- Ensure thorough cleaning of each run in multi-run welding.

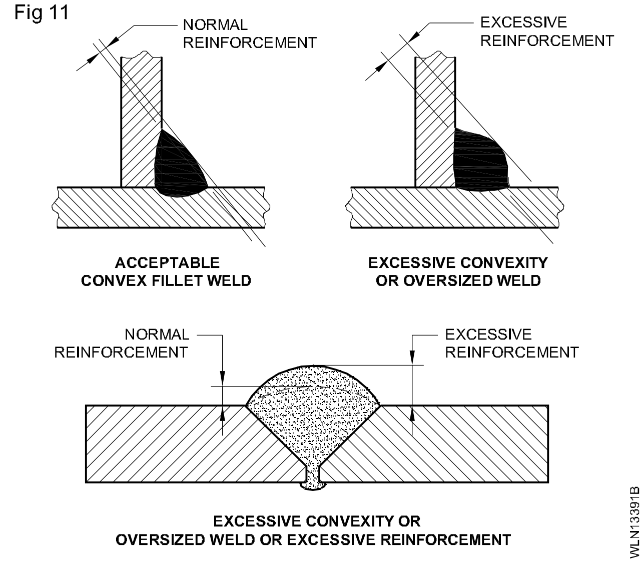
b Corrective actions

- For external/surface slag inclusion remove them using a diamond point chisel or by grinding and re-weld that area. For internal slag inclusions use gouging upto the depth of the defect and re-weld.

Excessive convexity (Fig 11)

This defect is also called as oversize weld or excessive reinforcement. It is the extra weld metal deposited in the final layer/covering run.

Fig 11



Excessive concavity/insufficient throat thickness

If the weld metal deposited into a butt or fillet weld is below the line joining the toes of the weld then this defect is called excessive concavity or insufficient throat thickness. (Fig 12)

Causes

- Incorrect bead profile due to improper weaving of electrode.
- Use of small dia. electrode.
- Excessive speed of welding.
- Wrong welding sequence when using stringer beads to fill the groove.
- Sagging of weld metal is not controlled in horizontal position.
- Electrode movement is not uniform.
- Improper electrode angle between the plate surfaces.

Remedies

- Lack of fusion.
- Mismatch.
- Uneven/irregular bead appearance.
- Excessive root penetration.

Fig 12