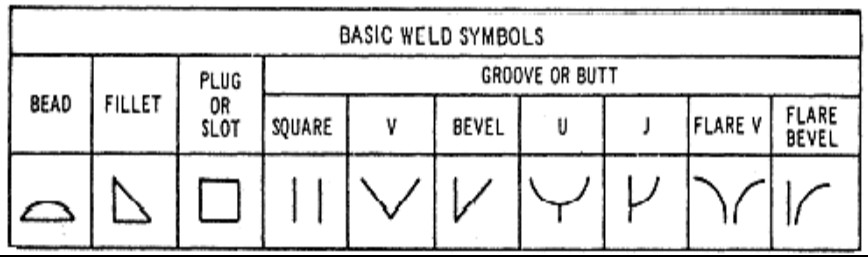
SUMMER – 17 EXAMINATIONS

Subject Code: **17455** **Model Answer** Page No: ____/ N

Important Instructions to examiners:

1) The answers should be examined by key words and not as word-to-word as given in the model answer scheme.
2) The model answer and the answer written by candidate may vary but the examiner may try to assess the understanding level of the candidate.
3) The language errors such as grammatical, spelling errors should not be given more importance. (Not applicable for subject English and Communication Skills)
4) While assessing figures, examiner may give credit for principal components indicated in the figure. The figures drawn by candidate and model answer may vary. The examiner may give credit for any equivalent figure drawn.
5) Credits may be given step wise for numerical problems. In some cases, the assumed constant values may vary and there may be some difference in the candidate's answers and model answer.
6) In case of some questions credit may be given by judgment on part of examiner of relevant answer based on candidate's understanding.
7) For programming language papers, credit may be given to any other program based on equivalent concept.

Q. NO.	MODEL ANSWER	MARKS	TOTAL MARKS
Q.1. A)	**Attempt any THREE**	**3X4**	**12**
a)	**Following are the types of weld joints:-** 1) Butt joint 2) Lap joint 3) Fillet weld 4) Edge joint 5) Corner joint 6) T-joint 7) Plug joint 8) Single V-groove joint 9) Double V-groove joint	**2m for types and 2m for draw any 4 symbols**	**4**

			
b)	ELECTRIC ARC DEFINATION: Electric arc or welding are can be defined as sustained Electric discharge through ionized gas, the discharge is initiated by a level of electron emitted from the hot cathode and maintained by thermal ionization of hot gas. This electrical discharge through an ionized gas produces good amount of heat energy which is used for joining various metals. Pulse Transfer Mechanism:- 1) Pulse arc welding is a controlled method of spray transfer welding which requires more power source, where as in short circuit type a standard power source is use. 2) Pulse arc transfer can be used on mild steel, stainless steel, aluminium and its alloy etc. 3)Operator can very the pulse height and the background current to obtain full control of both the heat input and the amount of metal deposited. 4)In spray transfer, droplets of metal are projected from the wire tip across the arc gap to the molten pool at a constant current. 5)Pulse arc welding enables droplets to be projected across the arc gap at regular frequency. 6)The transfer of metal from the wire tip to the molten pool occurs only at a period of pulse. 7)During the interval between pulses allow background current maintenance the arc to keep the wire tip molten but no metal is transfer.	**2m for def and 2m for exp**	**4**
c)	Weldability is the capacity of a material to be welded under the fabrication conditions imposed into a specific suitably designed structure and to perform satisfactorily in the intended service. Factors effecting are: 1) Composition of the metal 2) Brittleness and strength of metal at elevated temperature 3) Thermal properties of metal 4) Welding techniques,fluxing material and filler material 5) Proper heat treatment before and after the deposition of the metal.	**2m for def and 2m for factors**	**4**
d)	WELD METAL SOLIDIFICATION - The solidification of metals is usually considered to be a nucleation and growth process i.e., the transformation of a liquid	**4m**	**4m**

	phase to a solid normally occurs by a process of nucleation and growth Nucleation involves the creation of critical sized particles, (j.e. nuclei) of the new, (i.e., solid) phase and considerable supercoiling is usually necessary before the first solid nuclei are formed from which growth may proceed. - In all metallic systems, solidification is accompanied by the evolution of heat. In a pure metal the rate of growth is determined solely by the rate of heat extraction from the solid-liquid inter-face. . - The level of purity in welding operations is such that Segregation always occurs on solidification. As the alloy cools through the solidification range, solute is rejected at the solid liquid inter- face. - Since very little mechanical mixing of the liquid occurs in the immediate vicinity of the advancing interface, the rejected solute must be redistributed in the liquid by diffusion. - The freezing process is so rapid that diffusional processes cannot effectively remove the excess solute near the interface. Hence, solute enrichment occurs at the moving interface until a dynamic equilibrium is reached. The resulting dynamic equilibrium provides an excess of solute in the liquid near the interface with the solute content decreasing to the nominal liquid composition at some distance from the interface. As a result solidification of welding takes place.		
e)	**ARC BLOW:-**The unwanted deflection or wandering of welding areas from its intended path is termed as arc blow or arc bow. Arc blow is the result of magnetic disturbance which unbalance the symmetry of the self-induced magnetic field around the electrode, arc and work piece. Under arc blow, an arc may distort, deflect or rotate. Arc blow becomes severe when welding is carried out in confined spaces and corners on heavy metal plates, using a dc power sources.	**4m**	**4m**
1.B.	**Attempt any ONE**	**1x6**	**6**
a)	FOLOWING ARE THE TYPES OF FLAMES NEUTRAL FLAME OXIDISING FLAME REDUCING FLAME	1m for lisitng types and 5m for exp	**6m**

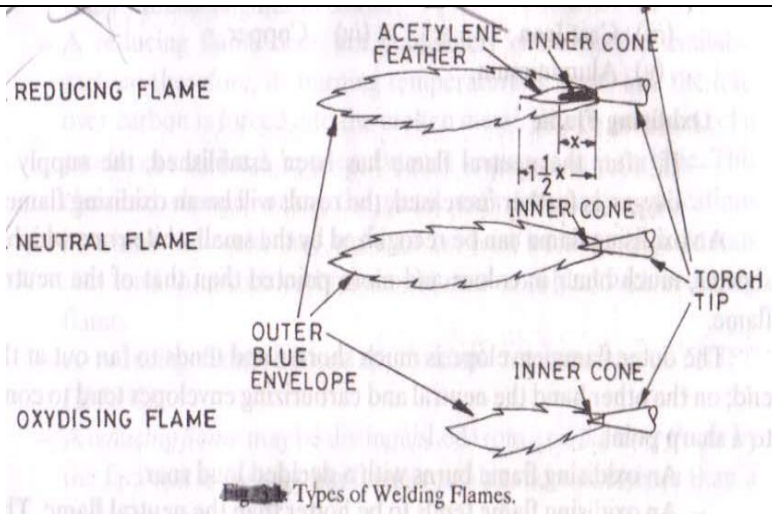


Fig. 3.1 Types of Welding Flames.

1) NEUTRAL FLAME:-

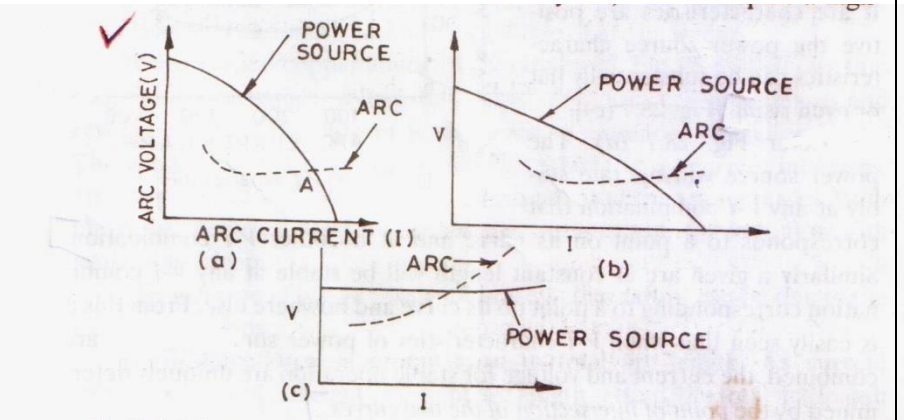
A neutral flame is produced when approximately equal volumes of Oxygen acetylene are mixed in the welding torch & burnt at the torch tip.The temperature of the neutral flame is of the order about 5900 F.The flame has a nicely defined inner cone which is light blue in colour.It is surrounded by an outer envelope which is much darker than blue. A neutral flame is named so because it effects no chemical change in the molten metal and therefore will not oxidize or carburize the metal.

2) OXIDISING FLAME:-

If after the neutral flame has been established the supply of an oxidising flame can be recognised by the small white cone which is shorter , much blue in colour & more painted than that of the neutral flame. The outer flame envelope is much shorter and tends to fan out at the end; An oxidising flame burns with a decided loud roar. An oxidising flame tends to be hotter than the neutral flame. This is because of excess oxygen & which causes the temperature to rise as high as 6300 F. Moreover, an excess of oxygen causes the weld bead and the surrounding area to have a scummy or dirty appearance.

3) Reducing Flame:-

If the volume of oxygen supplied to the neutral flame is reduced, the resulting flame will be a carburising flame or reducing flame which is rich in acetylene. A reducing flame does not completely consume the available carbon; therefore, its burning temperature is lower and the left- over carbon is forced into the molten metal. Metals that tend to absorb carbon should not be welded with reducing flame,A

	reducing flame has an approximate temperature of 5500 F.It can be recognized by the acetylene feather which exists in between the inner cone & the outer envelope.		
b)	**ARC CHARACTERISTICS:-**  Fig. 28.7. *V-I* characteristics of arc super-imposed on power sources characteristics. The behaviour of the arcs is generally describe with the details of arc characteristics. **VOLT AMPERE CHARACTERISTICS:-** In order to design power sources, their characteristics and the associated equipment to initiate and maintain a stable arc, the study of volt-ampere characteristics is necessary . if the arc characteristics are substantially flat, then to impart a high degree of self adjustment of arc consistent with stability, the volt-ampere characteristics of the power source must be slightly negative. If arc characteristics are positive the power source characteristics can be substantially flat or even rising. The power source will operate stably at any V-I combination that corresponds to a point on its curve and at no other V-I combination.	**3m for characte ristics and 3m for stability**	**6m**

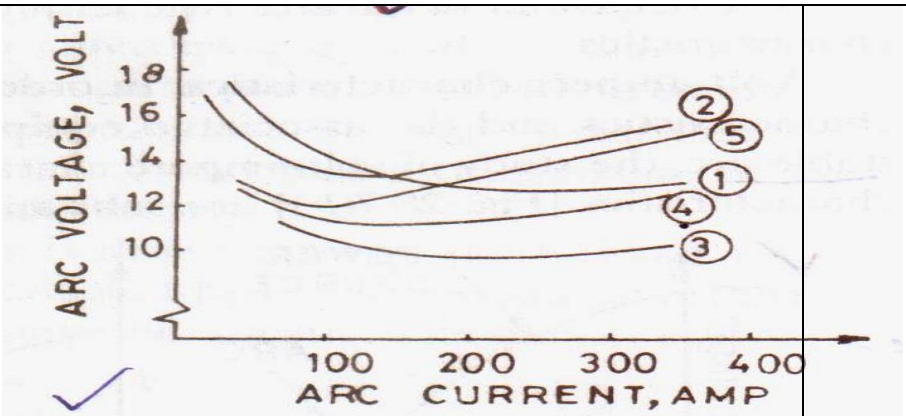


Fig. 28.8. (*i*) *V-I* characteristics

V-I CHARACTERISTICS UNDER DIFFERENT WELDING CONDITION.

1) Tungsten electrode 1/8”(3mm) diameter, electrode extension ½”(12.5 mm), normal mode of arc in argon.
2) Tungsten electrode 1/8”(3mm) diameter electrode extension ½”(12.5mm), cathode spot made of arc in argon.
3) Tungsten electrode 1/8” (3mm) diameter, electrode extension 1 ¼” (31mm), normal mode of arc in argon.
4) Thoriated tungsten electrode 3/32” (2.38mm0, electrode extension ½”(12.5), normal mode of arc in argon.
5) Thoriated tungsten electrode 5/32” (3.97 mm) diameter, electrode extension ½” (12.5 mm), cathode spot mode of arc in argon.

VOLTAGE –ARC LENGTH (V-L) CHARACTERISTICS

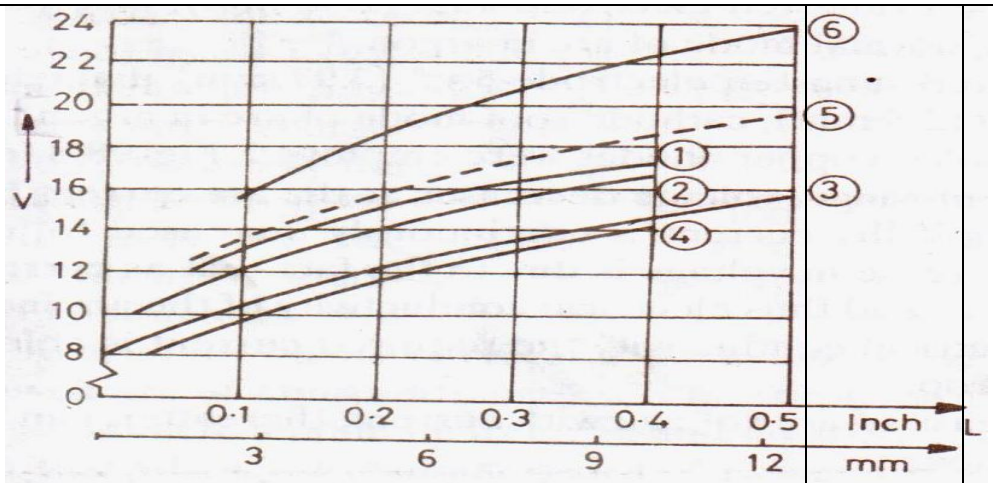


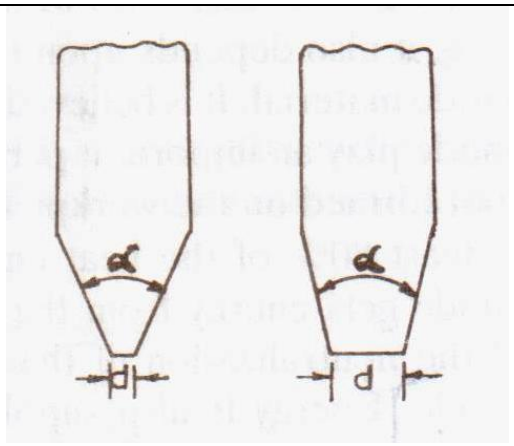
Fig. 28.9. (*i*) *V-L* characteristics.

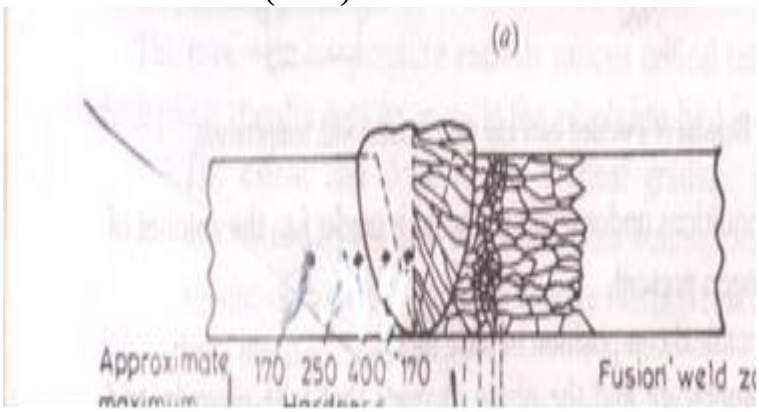
Arc length between the electrode (cathode) and job (anode) determines arc resistance and hence potential drop across the arc. In other words arc length determines the arc voltage and this voltage permits a certain flow of current as predicted from the characteristics of the power source. V-L characteristics also influence the electrode burn off rate.

ARC STABILITY

Arc said to be stable if it is uniform and steady. A stable arc will produce good weld bead and a defect-free weld nugget. The stability of a welding arc is governed by:

(a) Suitable matching of arc and power source characteristics. A little variation in arc length, i.e., arc voltage should not extinguish the arc.
(b) Continuous and proper emission of electrons from the electrode (say cathode) and thermal ionization in the arc column. Emissivity of pure tungsten cathode is improved by making it thoriated or zirconiated.
(c) Position and movements of cathode and anode spots.
(d) Arc length and arc current.
(e) Electrode tip geometry in TIG welding. Electrode tip geometry i.e. electrode with the geometry as shown in the figure A has more stable areas as compared to figure B.
(g) Conditions promoting Arc Blow.
(h) Presence of dampness, oil, grease, etc. on the surface of work piece.
(i) Limited practice on the part of the welder.

	 FIG A FIG:B		
Q.2	**ATTEMPT ANY TWO**	**2x8**	**16**
a)	**WELDING OF CAST IRON** Cast iron include a number of iron base metals that contain carbon (1.1% to 4.8 %), manganese (0.2% to 1.3%), sulphur (0.2%), silicon (0.8% to 3%), phosphorous (0.8%) In addition to the one mention above alloy of C.I also contain Ni, Cu, Cr, Mo, etc C.I can be classified as white C.I, grey C.I, malleable C.I , nodular C.I The process used for welding Cast iron are as follow:- a) Metal arc welding b) Oxy acetylene welding c) Brazing d) Thermit welding e) Brazed welding **METAL ARC WELDING**:- 1)The joint is carefully cleaned of all the dust, dirt, grease and paint. 2)A v-joint with an included angle of 60^{o}-90^{0} may be formed on the work piece.AC or DC power sources can be used for welding 3)Electrodes of C.I, nickel alloys, etc. can be used for welding. 4) arc is struck by touching the electrode wire the job. As the molten pool forms, the welding can be carried out in a normal way. 5) order to minimize the stress made up in the work piece skip welding can be used. 6)Skip welding is used in C.I where short length of weld metal is deposited on one part of seam, then the next length is done some distance away, keeping the sections far away from each other. Thus, localizing the heat. 7)Before welding preheating may be carried out and after welding is over the job is covered with insulating material to give a good quality weld.	**3m for state and 5m for exp**	**8**

	8) Forced heat treatment is carried out immediately after welding in that case there no need to cover with an insulating material.		
b)	Heat affected Zone (HAZ)  - Adjacent to the weld metal zone is the heat-affected zone that is composed of parent metal that did not melt but was heated to a high enough temperature for a sufficient period that grain growth occurred. - Heat -affected zone is that portion of the base metal whose mechanical properties and microstructure have been altered by the heat of welding - The heat-affected zone is subjected to a complex thermal cycle (sudden heating followed by rapid cooling) in which all temperatures from the melting range of the steel down to comparatively much lower temperatures are involved and HAZ therefore consists of a series of graded structures ringing the weld bead. - HAZ, usually contains a variety of microstructures. In plain carbon steels these structures may range from very narrow regions of hard martensite t6 coarse pearlite. This renders HAZ, the weakest area in a weld. Except where there are obvious defects in the weld deposit, most welding failures originate in the heat-affected zone. - The width of HAZ varies according to the welding process and technique; in arc welds it extends only a few mm from the fusion boundary, but in oxy-acetylene and electro slag welds it is somewhat wider. - The HAZ in low carbon steel of normal structure welded in one run with coated electrodes or by submerged arc process comprises three metallurgically distinguished regions. 1. The grain growth region 2. The grain refined region, . 3. The transition region The grain growth region. - Grain growth region is immediately adjacent to the weld metal	**4m (diag)** **4m (expl.)**	**8**

zone (fusion boundary).
- In this zone parent metal has been heated to a temperature well above the upper critical (A3) temperature. This resulted in grain growth or coarsening of the structure.

(b) The grain refined region
- Adjacent to the grain growth region is the grain refined zone.
- The refined zone indicates that in this region, the parent metal has been heated to just above the A 3 temperature where grain refinement is completed and the finest grain structure exists.

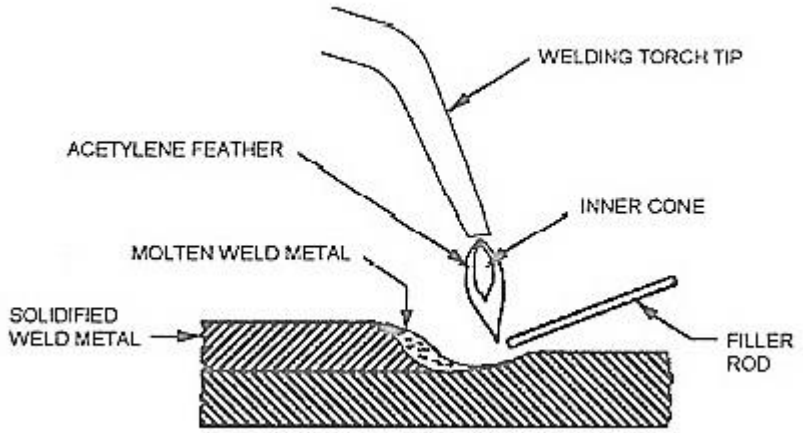
(c) The Transition zone
In the transition zone. a temperature range exists between the lower critical temperature and upper critical temperature transformation temperatures where partial allotropic recrystallization takes place

(c) Unaffected Parent Metal
- Outside the heat affected zone is the parent metal that was not heated sufficiently to change its microstructure.

c) **1m per point** **8**

SR	WELDING	BRAZING	SOLDERING
1	These are the strongest joints used to bear the load. Strength of a welded joint may be more than the strength of base metal.	These are stronger than soldering but weaker than welding. These can be used to bear the load up to some extent	These are weakest joint out of three. Not meant to bear the load. Use to make electrical contacts generally.
2	Temperature required is upto 3800°C of Welding zone.	It may go to 600°C in brazing	Temperature requirement is upto 450°C.
3	Work piece to be joined need to be heated till their melting point.	Work pieces are heated but below their melting point.	No need to heat the work pieces
4	Mechanical properties of base metal may change at the joint due to heating and cooling.	May change in mechanical properties of joint but it is almost negligible	No change in mechanical properties after joining
5	Heat cost is	Cost involved and	Cost involved and

		involved and high skill level is required.	skill required are in between others two	skill requirements are very low.			
	6	Heat treatment is generally required to eliminate undesirable effects of welding	No heat treatment is required after brazing.	No heat treatment is required			
	7	No preheating of workpiece is required before welding as it is carried out at high temperature.	Preheating is desirable to make strong joint as brazing is carried out at relatively low temperature	Preheating of workpieces before soldering is good for making good quality joint.			
Q.3	**ATTEMPT ANY TWO**				**2x8**	**16**	
a)	**WELDING OF ALLOY STEEL** The process used for welding of alloy steel are:- i) Oxy acetylene welding ii) Flux shielded metal arc welding iii) Submerged arc welding iv) Thermit welding v) Resistance spot welding vi) MIG welding **OXY ACETYLENE WELDING** When acetylene is mixed with oxygen in correct proportions in the welding torch and ignited, the flame resulting at the tip of the torch is sufficiently hot to melt and join the parent metal.The type of filler rod used depends upon the mechanical properties required. A high tensile steel rod will be more effective, the weld metal must match with the parent metal. A flux is used to counteract the oxidation of alloying element After welding post heat treatment is necessary to refine the grain structure. The oxy-acetylene flame reaches a temperature of about 3200°C and thus can melt all commercial metals which, during welding, actually flow together to form a complete bond				**2m for process 4m for exp And 2 m for sketch**	**8m**	

			
b)	The various defects in welds are as follows:- 1. Crack 2. Distortion. 3. Incomplete penetration 4. Inclusions 5. Porosity and blow holes. 6. Poor fusion 7. Poor weld bead appearance. 8. Spatter. 9. Undercutting. 10. Overlapping 1. Crack: The main causes of crack formation are as follows: 1. Rigidity of the joint, i.e., joint members not free to expand or contract when subjected to welding heat and subsequent cooling (localized stresses). 2. Poor ductility of base metal. 3. Hardenability, high S and C percentage of base metal. 4. Concave weld bead. 5. Fast arc travel speed. 6. Electrode with high H2 content. Remedies:- • Minimize shrinkage stresses using backstep or block welding sequence • Change welding current and travel speed • Weld with covered electrode negative; butter the joint faces prior to welding. • Change to new electrode; bake electrodes to remove moisture	**2m for state and 6m for any four defects**	**8m**

- Reduce root opening; build up the edges with weld metal
- Increase electrode size; raise welding current, reduce travel speed
- Use filler metal low in sulfur
- Change to balanced welding on both sides of joint
- Fill crater before extinguishing the arc; use a welding current decay device when terminating the weld bead.

DISTORTION

The various causes leading to distortion are:

1. More number of passes with small diameter electrodes.
2. Slow arc travel speed.
3. Type of joint. A V joint needs more metal to be deposited to fill the groove as compared to a U joint, thus leading to comparatively more distortion.
4. High residual stresses in plates to be welded.
5. Welding sequence being improper.

Remedies :-

1) Use of jigs and fixtures, clamps, presetting, wedging and proper tacking may minimize distortion.

- Reducing the metal weld volume to avoid overfill and consider the use of intermittent welding
- Minimising the number of weld runs
- Positioning and balancing the welds correctly round the axis
- Using backstep or skip welding techniques, which involves laying short welds in the opposite direction
- Making allowance for shrinkage by pre-setting the parts to be welded out of position
- Planning the welding sequence to ensure that shrinkages are counteracted progressively
- Shortening the welding time

INCOMPLETE PENETRATION

Various causes of incomplete penetration are as follows:

1. Improper joints. (For example, it is simpler to obtain full penetration in U joint as compared to J butt joint).
2. Too large root face.
3. Root gap too small.
4. Too small bevel angle.
5. Less arc current.
6. Faster arc travel speed.
7. Too small angle β (Normal β is 70--80°).
8. Too large electrode diameter.
9. Longer arc length.
10. Incorrect polarity when welding with direct current.

11. Wrongly held electrode.

Remedies:-
1) Electrode should be in the Centre of the joint.
- Follow correct welding procedure specification
- Maintain proper electrode position
- Reposition work, lower current, or increase weld travel speed
- Clean weld surface prior to welding

INCLUSIONS
The various factors promoting entrapment of inclusions are as follows:
1.Too high or too low arc current.
2.Long arcs.
3.Too large electrode diameter.
4.Insufficient chipping and cleaning of previous passes in multipass welding
5.Under-cutting (it can entrap slag particles).
6.Wrongly placed tack welds.
7.Too small included angle of the joint

Remedies:-
1) To prevent slag inclusions the slag should be cleaned from the weld bead between passes via grinding, wire brushing, or chipping.
2) This defect can only be repaired by grinding down or gouging out and re-welding.

POROSITY AND BLOW HOLES OR GAS POCKETS
The various factors leading to porous welds are listed below:
1. Improper (coating on the) electrode.
2. Longer arcs.
3. Faster arc travel speeds.
4. Too low and too high arc currents.
5. Incorrect welding technique (stringer beads are more apt to porosity as compared to moderately weaved beads).
6. Electrode with damp and damaged coating.
7. Scale, rust, oil, grease, moisture, etc. if present on the job surface,i.e., unclean job surface.
8. Improper base metal composition .

Remedies:-
- Use low-hydrogen welding process; filler metals high in deoxidizers; increase shielding gas flow

- Use preheat or increase heat input
- Clean joint faces and adjacent surfaces
- Use specially cleaned and packaged filler wire, and store it in clean area
- Change welding conditions and techniques
- Use copper-silicon filler metal; reduce heat input
- Use E60I0 electrodes and manipulate the arc heat to volatilize the zinc ahead of the molten weld pool
- Use recommended procedures for baking and storing electrodes
- Preheat the base metal
- Use electrodes with basic slagging reactions

POOR FUSION

Various causes promoting-poor fusion are as follows:

1. Lower arc current.
2. Faster arc travel speed.
3. Improper weaving technique.
4. Presence of oxides, rust, scale and other impurities (on the surfaces to be welded), which do not permit the deposited metal to fuse properly with the base metal.
5. Incorrect joint preparation (i.e., small included angle).
6. Incorrect electrode manipulation.

Remedies

1)Follow proper welding technique
2)Clean the weld metal from all oxides
3)The weld metal should be held properly before welding
4)Electrode diameter should be taken and held correctly

POOR WELD BEAD APPEARANCE

The following factors give rise to a poor bead appearance:

1. Limited practice on the part of the welder.
2. Arc length being not constant.
3. Improper welding technique and electrode manipulation.
4. Non-concentric and damaged electrode coating.
5. Magnetic arc blow (presence of undesired magnetic materials around the arc and work piece).
6. Job portion to be welded not easily accessible by the operator.
7. Poor earth and electrode holder (electric) connections.

Remedies

1)Skilled workers are required
2)Proper arc length should be maintained
3)Good quality electrode and proper holding of electrode should be taken care.

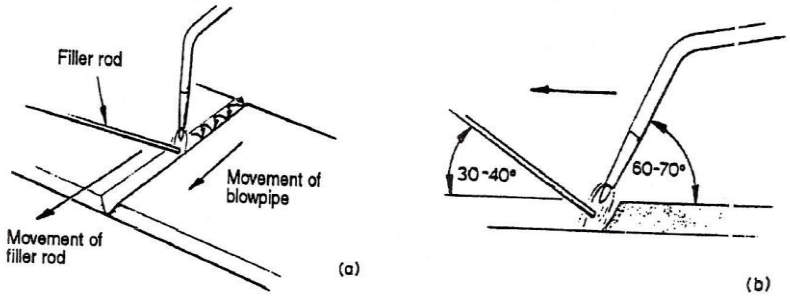
	4)Proper welding technique should be followed. SPATTER The spatter may be due to 1. Excessive arc current. 2. Longer arcs. 3. Damp electrodes. 4. Electrodes being coated with improper flux ingredients. 5. Arc blow making the arc uncontrollable. 6. Bubbles of gas becoming entrapped in the molten globule of metal, expanding with great violence and projecting small drops of metal outside the arc steam. RemediesP:- Spatter can be minimized by correcting the welding conditions and should be eliminated by grinding when present. UNDER-CUITING The main causes of undercutting are as follows: 1. Wrong manipulation and inclination of electrode and excessive weaving. 2. Too large electrode diameter. 3. Higher currents. 4. Longer arcs. 5. Faster arc travel speeds. 6. Magnetic arc blow. 7. Rusty and scaly job surfaces. Remedies:- Undercutting can be avoided with careful attention to detail during preparation of the weld and by improving the welding process. It can be repaired in most cases by welding up the resultant groove with a smaller electrode OVERLAPPING Overlapping occur due to 1. Lower arc current. 2. Slower arc travel speed 3. Longer arcs. 4. Improper joint geometry (i.e., root gap) 5. Incorrect electrode diameter. Remedies :- 1)The electrode diameter should not be too large to be manipulated conveniently and suitably 2)The base metal should be held properly 3)Proper arc length should be taken		

	4) The overlap can be repaired by grinding off excess weld metal and surface grinding smoothly to the base metal.		
c)	Brazing is defined as the group of joining processes wherein coalescence is produced by heating to a suitable temperature and by using a filler metal having a liquidus above 470 C and below the solidus of base3 metals. Cleaning and preparing the surface to be brazed is an important step. Clean oxide free and uncontaminated base metal surfaces are essential to ensure sound brazed joints of uniform quality. Grease, dirt, oxides,and other foreign matters or impurities will cause irregular flow of the filler alloy, lack of bond at spots and porosity in the joint. Base metals surface may be cleaned mechanically or chemically. The base metal surfaces may be ground, wire brushed, filed or abraded to remove oxides of scale and to expose clean metal. Similar results can be obtained by chemically etching or pickling the base metal surfaces. After chemical cleaning the chemical residues should be removed by washing the base metals surface with warm water otherwise they may attack the surface and form undesirable film.	**8m**	**8m**
Q.4. A.	**ATTEMPT ANY THREE**	**3X4**	**12**
a)	**Advantages :-** 1) It is probably the most versatile process 2) Welder can exercise better control over the temperature 3) The rate of heating and cooling is relatively slow 4) Equipment are more versatile,self sufficient,usually portable 5) The maintenance cost is low. 6. The cost and maintenance of the welding equipment is low when compared to that of some other processes. **Limitations**:- 1) Heavy sections cannot be joined economically 2) Flame temperature is less than that of the temperature of the arc	**2m for adv and 2m for limit**	**4**

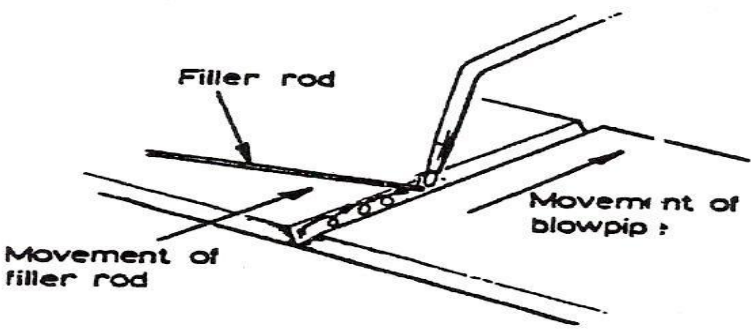
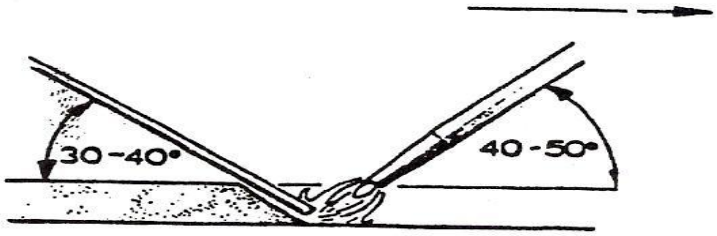
	3) Fumes produced during welding are irritating to the eyes, nose, throat and lungs. 4) Refractory metals and reactive metals cannot be joined 5) More safety problems arise. 6. Prolonged heating of the joint in gas welding results a larger heat-affected area. This often leads increased grain growth, more distortion and, in some cases, loss of corrosion resistance. 7. Acetylene and oxygen gases are rather expensive.		
b)	Welding electrodes can be classified as 1)Consumable electrodes :- a) Bare electrode b) Flux coated electrode 2) Non consumable electrode :- a) Carbon or graphite Electrode b) Tungsten Electrode:-This can be further classified as:- i) Pure Tungsten ii)Zirconated Tungsten iii) Thoriated Tungsten **ELECTRODE COADING CODES:-** • **AMERICAN SYSTEM:-** E XX XX or E 60 1 2 E XXX XX or E 100 1 5 • **BRITISH SYSTEM:** **L X X X L** **(first letter) (1^{st} digit) (2^{nd} digit) (3^{rd} digit) (last letter)** Example: E317M E145P • **INDIAN SYSTEM:-** **L X X X X X X L** **(1^{st}) (1^{st}) (2^{nd}) (3^{rd}) (4^{th}) (5^{th}) (6^{th})**		**4**

	(last **letter)** **letter**) **DIGITS** Example:E307411P		
c)	**Tig welding process associated with welding of aluminum**:- • This welding is most commonly used method for welding of Aluminum nowadays • Thinner gauges of Aluminum can be joined without a filler metal • Gas welding uses a flux, whereas TIG welding makes use of an inert gas to prevent any reaction between the molten weld metal and the atmosphere • TIG welding involves sticking an arc between a tungsten electrode and work piece to provide heat for joining • A separate filler rod is used when welding a thicker work piece • Before welding the work piece is cleaned properly with oil, Greece, dirt, paint, moisture,etc. • For TIG welding of Aluminum either AC or DC supply is used • Argon is usually used for TIG welding of Al. Helium is sometimes used for thicker sections mixture of these is also used for welding Al • For AC welding unalloyed tungsten (zirconium) electrode are mostly used. • It is an arc welding process where in coalescence is produced by heating the jaw with an electric arc struck between tungsten electrode and job.	**4m**	**4m**
d)	Effect of welding on properties of metal - Welding involves many metallurgical phenomena. Welding operation somewhat resembles to casting. - In all welding processes, except cold welding, heating and cooling 'are essential and integral parts of the process. High degrees of superheat in the weld metal may be obtained in many fusion welding processes. Heat affected zone 1. The grain growth region 2. The grain refined region, . 3. The transition region The grain growth region.		

	- Grain growth region is immediately adjacent to the weld metal zone (fusion boundary). - In this zone parent metal has been heated to a temperature well above the upper critical (A3) temperature. This resulted in grain growth or coarsening of the structure. (b) The grain refined region - Adjacent to the grain growth region is the grain refined zone. - The refined zone indicates that in this region, the parent metal has been heated to just above the A 3 temperature where grain refinement is completed and the finest grain structure exists. (c) The Transition zone In the transition zone. a temperature range exists between the lower critical temperature and upper critical temperature transformation temperatures where partial allotropic recrystallization takes place (c) Unaffected Parent Metal - Outside the heat affected zone is the parent metal that was not heated sufficiently to change its microstructure. **OR** Effects of various elements on welding rods is listed below. Carbon During solidification grain growth occurs, resulting to increase in, hardness and residual stresses. The metal shows cracks and brittleness. dutility is poor. Manganese The presence of 1.1% manganese raises the yield point and ultimate tensile strength of the weld to the maxi- mum limit. Excessive manganese along with the carbon content increases hardness, hardenability and tendency to cracks. Silicon Silicon is a strong deoxidiser but excess amount acts as impurity in steels. Sulphur Sulphur readily combines with iron'and forms iron sulphide (FeS). It has low melting point and reduces adhesiveness between adjacent grains of the metal. Phosphorus Phosphorus forms iron phosphides steel. It decreases the plasticity of the metal. In cast iron welding phosphorus content from 0.5 to 1.0% is desirable. It increase fluidity of the molten metal and helps the filling grooves properly. Nickel The properties of nickel are similar to maganese.It increases strength, hardness, hardenability.. toughness and ductility of steel. Chromium Chromium forms complex carbides increases the hardness without decreasing the toughness when added in quantities up to 1.5 Vanadium It's a strong oxidizer When used as an alloy it		

	strengthens the weldability and increases hardenability Tungsten Tungsten reacts with iron and forms complex carbides. It affects the properties of steel even in small quantities by increasing harnessand strength. Molybdenum The properties of molybdenum are similar to tungsten and act a cheaper substitute of tungsten.		
Q.4 B.	**ATTEMPT ANY ONE**	**1X6**	**6**
a.	**F**ollowing are the fluxes used in gas welding:- The fluxes are fusable, non-magnetic and maybe used either by applying directly onto the surface of the base metal. 1) Boric acid, Fluorspar 2) Sodium Chloride 3) Soda ash 4) Magnesium silicate 5) Lime 6) Lithium chloride **7)** Potassium chloride Filler metal:- Filler metal is a material that is added to the weld pool to help in filling the gap. Filler rods are available in variety of composition and sizes and has same or nearly the same chemical composition to that of the base metal. Filler metal is available in rod form, or a wire form. Two types of welding rods available for gas welding aluminum alloys are the 1100 and 4043 rods. Following are the two types of techniques:- Leftward Welding  In this method of welding, the blowpipe should be grasped firmly, ensuring that the wrist is free to move. The weld is commenced on the right-hand side of the seam; working towards the left-hand side,	**1m for filler metal 1m for fluxes and 4m for any one techniqu e**	**6**

	as shown in illustration (a) below. The blowpipe is moved forward with the flame pointing in the direction of the welding, with the filler rod being held in front of the flame. The angles of inclination of the blowpipe and Eller rod are shown clearly in illustration (b). The blowpipe is given small sideways movements, while the filler red is moved steadily across the weld seam. The filler rod metal is added using a backward and forward movement of the rod, allowing the flame to melt the bottom edges of the plates just ahead of the weld pool. It is important that the filler rod is not held continuously in contact with the weld pool, or the heat from the flame cannot reach the bottom edges of the joint. **OR** Rightward Welding In this method, the welding is commenced on the left-hand side of the seam, working towards the right-hand side, as shown in the top illustration. The blowpipe points in the direction of the welded seam and moves in a straight line along the seam. The filler rod is held at an angle of 30/40° (see second illustration) and describes a series of loops as it is moved forward. When using this method it is not necessary to bevel the edges of the plates for thicknesses up to 5/16 in., and for plates over this size a vee with an included angle of only 60° is required. The differences in edge preparation, blowpipe direction and filler rod movement are the major factors to be considered when comparing the rightward and leftward techniques.		

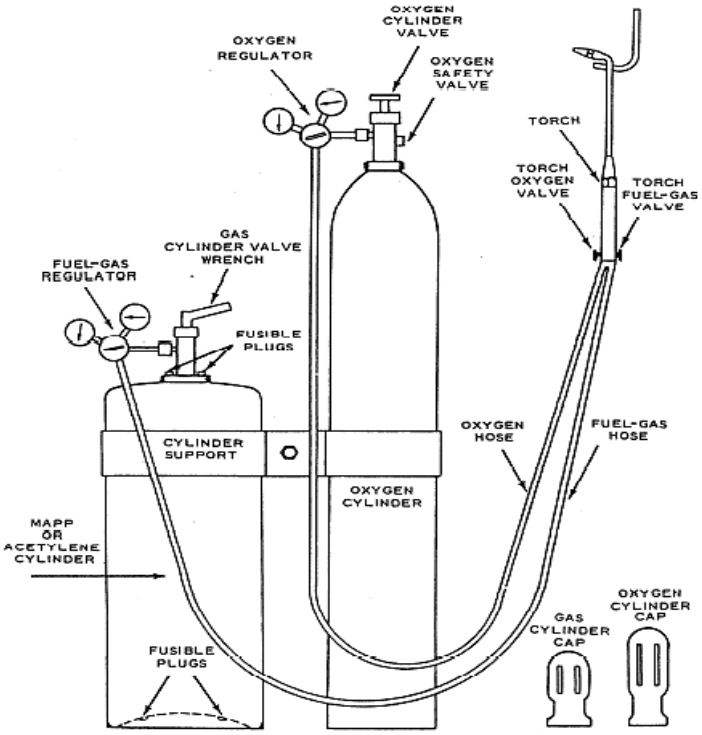
	 		
b)	**ARC LENGTH:-** • A longer arc results in poor weld and trends to wonder over considerable area on the work piece. • Longer arc causes low strength, poor ductility, porosity and its also prevents the concentration of deposits and causes excessive overlap and waste of material. • With shorter areas the flame consisting of vapour us coming out of the arc act as production by the surrounding electrode metal and are pool. • The absorption of this outside gases can be prevented. Section factors for power sources: The following factors influence the selection of a power source: 1. Available power (AC or DC, single phase, etc.). 2. Available floor space. 3. Initial costs and running costs. 4. Location of operation. 5. Personnel available for maintenance. 6. Versatility of equipment. 7. Required output. 8. Efficiency. 9. Type of electrodes to be used and metals to be welded.	**4m for arc length and 2m for any four factors**	**6**
Q.5	**ATTEMPT ANY TWO**	**2x8**	**16**

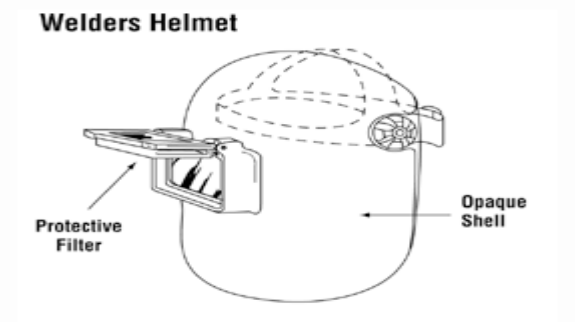
a.	**MANUFACTURING OF ELECTRODE:-** **1)** There are two methods of applying flux coating on the core wire:- **a) DIPPING METHOD** **b) EXTRUSION METHOD** **DIPPING METHOD:-** **1.** No. of core wires are cut to definite length and are clamped vertically in a fixture and are dipped in the bath of molten flux. **2.** When a suitable thickness of flux gets adhered to the core wire the fixture is raised and the flux is allowed to dry. **EXTRUSION:-** **1.** The core wire and the thick paste of flux simultaneously under pressure pass through the die thus attaching a thick paste coating in the core wire. **2.** The coating thickness depends upon the die opening and can be varied **3.** The flux from the gripping end of electrode is removed by an electrically rotated wire brush after which the electrodes are fed to oven where they are dried and baked to remove excess moisture. **4.** There after the electrode are sorted, wrapped put into packets and the bulk is boxed into wooden case. **CARE AND STORAGE OF ELECTRODE:-** **1.** Electrodes with damp coating will produce porosity and cracks in the joint electrodes with damage coating will produce joints of poor mechanically properties. **2.** In order to avoid the damage to the coating **3.** Electrode during storage should neither bend nor deflect **4.** Electrodes packets should not be thrown or pilled over each other **5.** Electrodes should be store in dry and well ventilated store rooms **6.** Before using the electrodes it may be dried as per the manufacture recommendation **7.** All electrodes especially the costlier one should be used. All they are left hardly 40-50mm **8.** Electrodes should be preferably retain in original packing for identification. Loss of identity of electrodes can waste lots of	**4m for methods and 4 m for care and storage**	**8m**

	time in recognizing them properly.		
b.	Heat Tretment:- Heat treatment is the heating and cooling of metals to change their physical and mechanical properties, without letting it change its shape NEED OF HEAT TREATMENT AFTER WELDING:- Postweld heat treatment (PWHT), defined as any heat treatment after welding, is often used to improve properties of a weldment. In concept, the PWHT can encompass many different potential treatments; fabrication, the two most common procedures however, in steel used are **post heating** and **stress relieving** **Heat treatment used in welding:-** 1)**Post Heating:** **Hydrogen induced cracking (HIC)** often occurs when high levels of ambient hydrogen permeate into a material during welding. By heating the material after welding, it is possible to diffuse hydrogen from the welded area, thus preventing HIC. This process is known as post heating and should begin immediately after the weld is completed. Rather than being allowed to cool, the material needs to be heated to a certain temperature depending on the type and thickness of the material. It should be held at this temperature for a number of hours dependent on the thickness of the material. 2) **Stress Relieving:** By the time it's complete, the welding process can leave a large number of residual stresses in a material, which can lead to an increased potential for stress corrosion and hydrogen induced cracking. PWHT can be used to release these residual stresses and reduce this potential. This process involves heating the material to a specific temperature and then gradually cooling it.	**2m** **2m** **4m**	**8m**
c.	**Principle of operation** Brazing involves the melting of a comparatively low melting point	**4m for**	**8m**

	filler metal against the base metal piece to be joint while they are clean and free from oxides, oil, grease etc. It is not necessary to melt the base metal. The molten filler metal **1]** wets the base metal surfaces **2]** spreads along the joint to be brazed by capillary action. **3]** adheres and solidifies to form the brazed joint. Capillary flow plays a major role in producing good basements provided the base metal surfaces are wet by the molten filler material. The flux which is employees during brazing melts at a lower temperature than the brazing filler metal, wets the surfaces to be brazed, remove the oxide film and gives clean surfaces. Since the capillary attraction between the base metal and the filler material is at least several times higher than that between the waste material and the flux the filler material replaces the flux and flows into the narrow space of joint between the surfaces by capillary attraction. The narrow at the joint better will the capital flow. The joint up on cooling to room temperature will be found filled with solid filler material and the flux now also solidified will be found on the joint periphery. The higher fluidity of the molten filler material is also an important factor in Obtaining successful brazing joints. **Applications of brazing** **1]** brazing can be used to join a large variety of dissimilar metals,wrought metals and porous metals. **2]** thin walled tubes and light gauge sheet metal assemblies not joinable by welding can be joined by brazing. 3]can be used to join ferrous and nonferrous metals, for maintenance as well as fabrication purposes 4]Brazing is used for fastening of pipe fittings, tanks, carbide tips on tools, radiators, heat exchangers, electrical parts, axles, etc.. 5]It is used to join band saws, parts of bicycle such as frame and rims. **Limitations of brazing** **1]** Size limitations of the parts to be brazed is of major importance. Change the outer area to be brazed must be heated, large caste sections or large heavy plates cannot be easily brought up to temperature.	**principle** **2m for any two application** **2m for any two limitation**	

	2] brazing requires tightly meeting parts to ensure capillary flow of filler metal. This involves expensive machining to attain the desired fit. **3]** flux residues if not properly removed can cause corrosion. **4]** brazed joints do not give satisfactory results when used at elevated temperatures. **5]** a certain degree of skill is required to perform the brazing operation, personal limitation may rule out the process. **6]** brazing fluxes and filler roads may toxic fumes and poisonous vapours.		
Q6	**ATTEMPT ANY FOUR**	**4x4**	**16**
a)	Following are the equipment used in gas welding:- 1) Oxygen gas cylinder 2) Acetylene gas cylinder 3) Oxygen gas hose 4) Acetylene gas hose 5) Welding torch 6) Trolley 7) Filler rod 8) Flux 9) Protecting clothes	**2m for listing and 2 m for diag of any one**	**4m**


OXYGEN CYLINDER VALVE
OXYGEN REGULATOR
OXYGEN SAFETY VALVE
TORCH
TORCH OXYGEN VALVE
TORCH FUEL-GAS VALVE
GAS CYLINDER VALVE WRENCH
FUEL-GAS REGULATOR
FUSIBLE PLUGS
CYLINDER SUPPORT
OXYGEN HOSE
FUEL-GAS HOSE
OXYGEN CYLINDER
MAPP OR ACETYLENE CYLINDER
OXYGEN CYLINDER CAP
GAS CYLINDER CAP
FUSIBLE PLUGS


Welders Helmet
Protective Filter
Opaque Shell

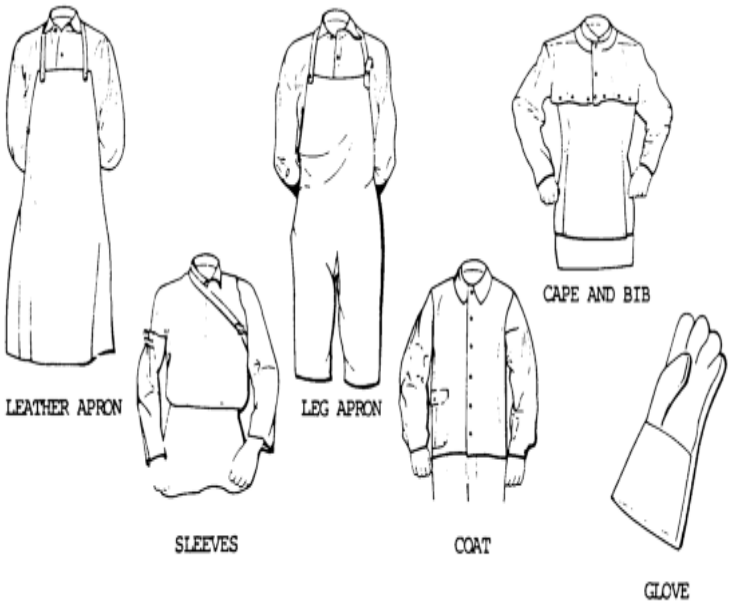
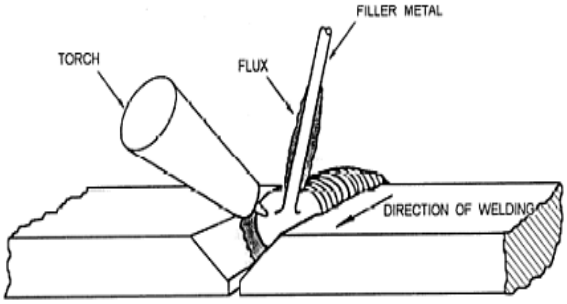


Figure 2-4. Protective clothing.



b)	**Polarity:** With direct current (DC) the welding circuit can either be straight, or reverse polarity. When the machine is set for straight polarity, the current flows from the electrode to the weld surface and creates considerable heat in the metal.Polarity is a term used in electricity, magnetism, and electronic signaling.A welder should know the meaning of polarity, and recognize what effect it has on the welding process. With few exceptions, electrode-positive (reversed polarity) results in deeper penetration. Electrode-negative (straight polarity) results in faster melt-off of the electrode and, therefore, faster deposition rate.	**2m for polarity and 2 m for factors**	**4m**

	Factors to be considered are as follows • Selection of type of welding current • Electrode size and coating factor • Metal transfer and Weld beads • Type of material to be welded		
c)	METAL-ARC WELDING OF MILD STEEL.:- Procedure - A Vee joint with included angle of 60° to 90° may be formed (on the workpieccs to be joined) by chipping or machining. Notching or studding may be adopted to increase the strength of the weld joint - The joint is carefully cleaned of all dust, dirt, oil, grease and paint - Electrodes of cast iron, mild steel, austenitic stainless steel, nickel alloys etc., may be employed for welding mild steel. - The arc is struck by touching the electrode with the job. As the molten pool forms, the welding is carried out in the normal way. In order to minimize the stresses set up in the workpiece, the welds may be laid in short runs (skip welding) and then each allowed to cool. Peening the weld while hot also relieves stresses. Skip welding technique is very successful in arc welding of cast iron. A short length of weld metal is deposited in one part of the seam then the next length is done some distance away, keeping the sections as far away from each other as possible thus localizing the heat. Before welding, preheating (600-700C) may be carried out and after the welding is over, the job may be covered with an insulating material to produce good quality welded joints. In some situations post-heat-treatment is carried out immediately after welding. In that case there is no need to cover the weld etc., with an insulating material. An AC or DC power source may be employed for welding. The current required to weld with 6 and 10 mm cast iron electrodes is approximately 300 and 400 Amps respectively.	**4m**	**4m**
d)	Advantages:- 1)High electrical conductivity Nd thermal conductivities. 2)Low melting temperature rage.	**2m** **(any 2)**	**4m**

<table>
<tr><td></td><td>3)Softens more rapidly and at lower tempratures low inertia welding machine heads are required.

limitations:-

1) High shrinkage during solidification can cause cracking.

2) Presence of oxide coating on the surface of no ferrous metals decreases electrode life.

3) Produces lower strength weld.</td><td>2m

(any 2)</td><td></td></tr>
<tr><td>e)</td><td>WELDING METALLURGY OF ALUMINIUM

• Aluminium is a silvery white metal which is light in weight.
• It is a good conductor of heat and electricity
• It has a higher resistance to corrosion, very ductile, non-magnetic.
• The melting point of pure aluminium is 659^{o}C
• Although pure aluminium is not particularly strong, if forms high strength alloys in conjunction with other metals such as Cr, Ni, FE, Mg, Si, Mn, Zn.
• Aluminium and its alloys can be forged, welded, rolled, casting, extruded etc.
THE PROCESS OF WELDING ON ALUMINIUM ARE AS FOLLOWS:-
• TIG Welding
• MIG Welding
• Oxy gas welding
• Brazing
• Metallic arc welding
• Resistance welding, etc.</td><td>4m</td><td>4m</td></tr>
<tr><td>f)</td><td><table><tr><td>Horizontal position</td><td>Vertical Position</td></tr><tr><td>In the horizontal position, the weld’s axis is the horizontal plane.</td><td>With a vertical position, the weld’s axis is largely in a vertical or upright position.</td></tr><tr><td>Horizontal position is a little easy to weld as compared to</td><td>Vertical position is difficult to weld as compared to horizontal</td></tr></table></td><td>4m(1m per point)</td><td>4m</td></tr>
</table>

	vertical position	position		
	Horizontal welding is done in horizontal plane in horizontal weld axis	Vertical welding is done in a vertical line, usually from bottom to top; however, on thin material downhill or downhand welding may be easier.