LANDMARK UNIVERSITY, OMU-ARAN

COLLEGE: COLLEGE OF SCIENCE AND ENGINEERING
DEPARTMENT: MECHANICAL ENGINEERING

LECTURE NOTE – 2.
ENGR. ALIYU, S. J.
GEC 218.
ALPHA 2016-17

ENGR. ALIYU, S.J.
Course title: Workshop Technology .
Course Units: 2 UNITS
Course Content :–
Workshop practice investigations and report submission on selected workshop practical's and projects drawn from introduction to mechanical, electrical & information engineering, civil, chemical, and agric and biosystem engineering and Workshop Technology courses. Use of hand tools, and safety measures in these fields.

INTRODUCTION TO WELDING TECHNOLOGY

Welding is a fabrication process used to join materials, usually metals or thermoplastics, together. During welding, the pieces to be joined (*the work-pieces*) are melted at the joining interface and usually a filler material is added to form a pool of molten material (*the weld pool*) that solidifies to become a strong joint. In contrast, *Soldering and Brazing* do not involve melting the work-piece but rather a lower-melting-point material is melted between the work-pieces to bond them together.

ESTIMATION IN WELDING SHOP.

Welding technology is gaining importance in the field of fabrication, reconditioning of worn parts, and has become principal joining process of numerous metal products of different sizes and shapes. The welded joints gives the strength equal to that of original metal. With the increase in the importance of welding, estimation of welding cost has become necessary.

Welding is the process of joining two or more metal (materials) pieces by heating them up to the desired temperature with or without the application of pressure and with or without the use of filler metal.

TYPE OF WELDING JOINTS.

Various different types of weld joints are shown below.

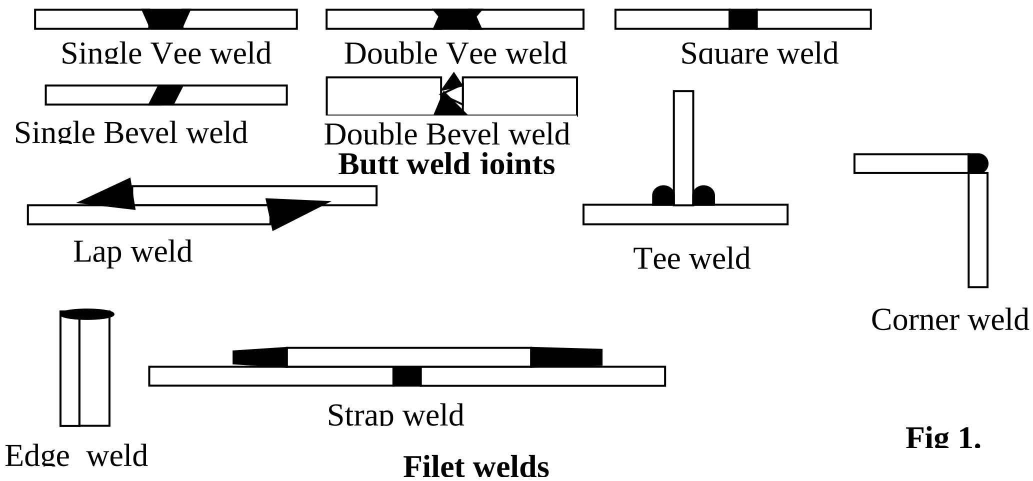
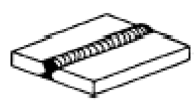


Fig 1.

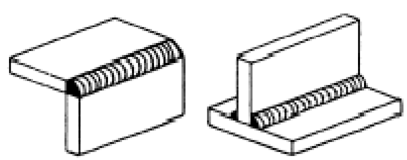
Types of Welded Joints

The weld joint is where two or more metal parts are joined by welding. The five basic types of weld joints are the butt, corner, tee, lap, and edge.

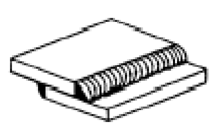
Butt Joint: it is used to join two members aligned in the same plane. This joint is frequently used in plate, sheet metal, and pipe



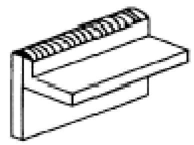
Corner and Tee Joints: these joints are used to join two members located at right angles to each other. In cross section, the corner joint forms an L-shape, and the tee joint has the shape of the letter T.



Lap Joint: this joint is made by lapping one piece of metal over another. This is one of the strongest types of joints available; however, for maximum joint efficiency, the overlap should be at least three times the thickness of the thinnest member of the joint.



Edge Joint: it is used to join the edges of two or more members lying in the same plane. In most cases, one of the members is flanged, as seen in the figure. This type is frequently used in sheet metal work for joining metals 1/4 inch or less in thickness that are not subjected to heavy loads.



Edge preparation of joints:

Welding without edge preparation will not be strong enough because two metals may not be having uniform contact throughout the depth. Therefore edge preparation is very important for getting strong joint by welding. The surfaces should also be cleaned so as to make them free from foreign material and should not be oily or greasy.

Types of Welding

There are many different types of welding processes and in general they can be categorized as:

Gas Welding: In this method a focused high temperature flame generated by gas combustion is used to melt the work-pieces (and filler) together. The most common type of gas welding is Oxy-fuel welding where acetylene is combusted in oxygen.

GAS WELDING.

In case of gas welding, the following two techniques are adopted in practice.

1. Left ward or fore-hand welding.
2. Right ward or back-hand welding.

1. Left ward or fore-hand welding.

In this type of welding, welding is started from the right hand side of the joint and proceeds towards the left hand side. This method is suitable for welding plates up to 3mm thickness without edge preparation and up to 5mm thickness with edge preparation.

2. Right ward or back-hand welding.

In this type of welding, welding is started from the left hand side of the joint and proceeds towards the right hand side. This method is suitable for steel plates which are of more than 5mm thickness. In plates up to 8mm thickness plates should be bevelled to about 30^0.

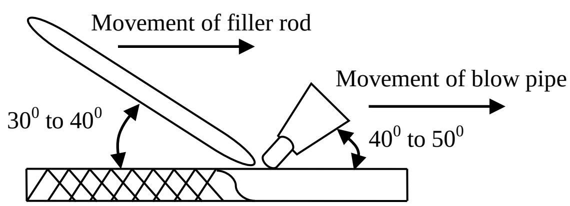


Fig. 2

Gas welding can only be done on plates up to 25mm thickness. The table 1 below is useful in estimating the welding cost in case of gas welding.

Estimation of welding cost.

For estimating the welding cost, the following elements should be considered.

1. Preparation cost: It includes the cost of edge preparation, proper fit up and other elements before actual starting of welding.
2. Actual welding cost: this includes two welding costs.
   a. Cost of material used in welding process like O_2, C_2H_2, filler rod, and flux etc.
   b. Labour cost: It should be obtained from organisational wages sheets.
   c. Welding finishing cost: this includes, the expenditure made in finishing the welding joint after welding. Post welding treatment (such as heat treatment) cost can also be taken into account.
   d. On-cost: All the other overheads on the equipment and other facilities connected with welding operations should be considered.

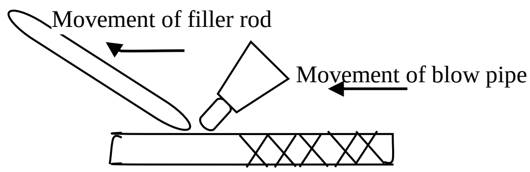


Fig. 3

Resistance Welding: Resistance welding involves the generation of heat by passing a high current (1000–100,000 A) through the resistance caused by the contact between two or more metal surfaces where that causes pools of molten metal to be formed at the weld area. The most common types of resistance welding are *Spot-welding* (using pointed electrodes) and *Seam-welding* (using wheel-shaped electrodes).

Energy Beam Welding: In this method a focused high-energy beam (Laser beam or electron beam) is used to melt the work-pieces and thus join them together.

Solid-State Welding: In contrast to other welding methods, solid-state welding processes do not involve the melting of the materials being joined. Common types of solid-state welding include; ultrasonic welding, explosion welding, electromagnetic pulse welding, roll welding, friction welding (including friction-stir-welding), etc.

Table 1

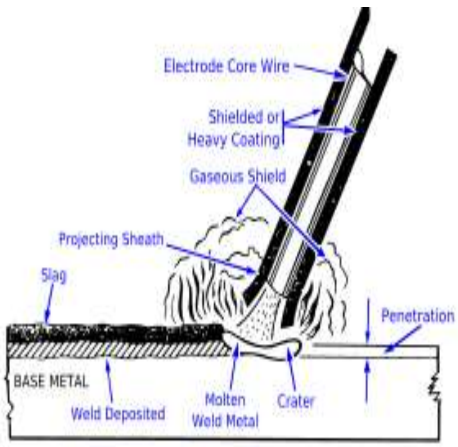
Plate thickness in mm	Welding technique	Filler rod dia. in mm.	O_2 consumption in cu. m/hr.	Acetylene consumption in cu.m/hr.	Welding time per m in min.	Length of filler rod required *l* m of welding in

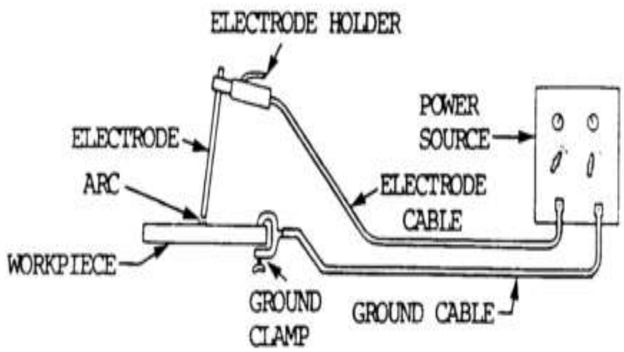
						m.
1	Leftward	1.0	0.04	0.02	9 to 11	1.0
2	,,	2.0	0.10	0.04	10 to 12	1.5
3	,,	2.5	0.12	0.07	12 to 13	1.6
4	,,	3.0	0.15	0.10	13 to 15	2.6
5	,,	3 to 4	0.21	0.14	15 to 17	4.0 to4.8
5	Rightward	2.5	0.3	0.20	16 to 18	3.3
6	,,	3.0	0.4	0.25	18 to 20	3.6
8	,,	4.0	0.5	0.30	20 to 28	3.6
10	,,	5.0	0.7	0.5	30 to 35	4.5
15	,,	6.0	1.0	0.60	45 to 50	6.8
20	,,	6.0	1.2	0.80	60 to 67	10.0
25	,,	6.0	1.6	0.90	85 to 100	16.0

Arc Welding: A welding power supply is used to create and maintain an electric arc between an electrode and the base material to melt metals at the welding point. In such welding processes the power supply could be AC or DC, the electrode could be consumable or non-consumable and a filler material may or may not be added.

The most common types of arc welding are:

- *Shielded Metal Arc Welding* (SMAW): A process that uses a coated consumable electrode to lay the weld. As the electrode melts, the (flux) coating disintegrates, giving off shielding gases that protect the weld area from atmospheric gases and provides molten slag which covers the filler metal as it travels from the electrode to the weld pool. Once part of the weld pool, the slag floats to the surface and protects the weld from contamination as it solidifies. Once hardened, the slag must be chipped away to reveal the finished weld.





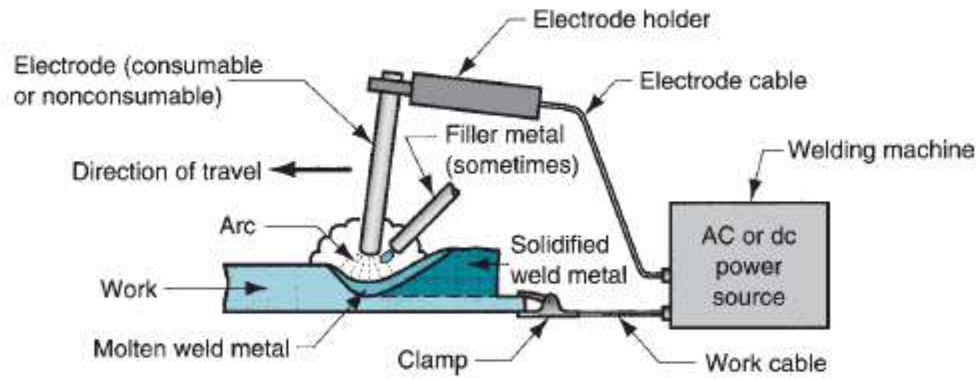


Fig- 4. The basic configuration and electrical circuit of an arcwelding process.

- *Gas Metal Arc Welding* (GMAW): A process in which a continuous and consumable wire electrode and a shielding gas (*usually an argon and carbon dioxide mixture*) are fed through a welding gun.
- *Gas Tungsten Arc Welding* (GTAW): A process that uses a non-consumable tungsten electrode to produce the weld. The weld area is protected from atmospheric contamination by a shielding gas, and a filler metal that is fed manually is usually used.

ARC WELDING

Arc welding (AW) is a fusion-welding process in which coalescence of the metals is achieved by the heat of an electric arc between an electrode and the work. A generic AW process is shown in Figure 4. An electric arc is a discharge of electric current across a gap in a circuit. It is sustained by the presence of a thermally ionized column of gas (called a plasma) through which current flows. To initiate the arc in an AW process, the electrode is brought into contact with the work and then quickly separated from it by a short distance. The electric energy from the arc thus formed produces temperatures of 5500^0C ($10{,}000^0$F) or higher, sufficiently hot to melt any metal. A pool of molten metal, consisting of base metal(s) and filler metal (if one is used) is formed near the tip of the electrode. In most arc welding processes, filler metal is added during the operation to increase the volume and strength of the weld joint. As the electrode is moved along the joint, the molten weld pool solidifies in its wake. Movement of the electrode relative to the work is accomplished by either a human welder (manual welding) or by mechanical means (i.e., machine welding, automatic welding, or robotic welding). One of the troublesome aspects of manual arc welding is that the quality of the weld joint depends on the skill and work ethic of the human welder. Productivity is also an issue. It is often measured as arc time (also called arc-on time) — the proportion of hours worked that arc welding is being accomplished:

$$\text{Arc time} = (\text{time arc is on}) / (\text{hours worked}) \quad \ldots\ldots \text{A1}$$

This definition can be applied to an individual welder or to a mechanized workstation. For manual welding, arc time is usually around 20%. Frequent rest periods are needed by the welder to overcome fatigue in manual arc welding, which requires hand eye coordination under stressful conditions. Arc time increases to about 50% (more or less, depending on the operation) for machine, automatic, and robotic welding.

ELECTRIC WELDING.

Electric welding is very economical because it required very less time than required for gas welding. The table below provides the approximate data which helps in estimating the cost of electric welding.

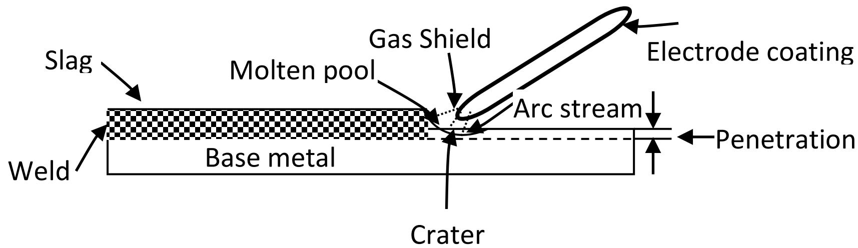


Fig. 5

Table 2. Electric Welding.

Plate thickness in mm	Electrode no.	Length of electrode required I m of welding.	Welding time in min/m.	Power consumption per m length in kWh.
3	10	0.50 to 0.60	6 to 7	1.2
5	8	0.70 to 0.80	10 to 12	2.0
10	6	1.00 to 1.20	20 t0 25	3.0
15	6	1.75 to 2.00	35 to 40	3.7
20	4	2.00 to 2.60	40 to 45	4.8

Estimation of Arc welding cost.

For estimating the cost of arc welding the following costs are included:

1. Material cost: It includes the cost of the electrode.
2. Labour cost
3. Power charges.
4. Finishing cost including post welding treatment cost.
5. On-cost.

Factors affecting welding cost.

There are certain factors which affect largely on the welding cost. These factors are as follows:

1. Time required for handling and setting the job and equipment in correct position.
2. Time required for fixing the fixtures.

3. Rest and fatigue time allowance. These are generally taken as 5 to 10% of the total time for which an operator remains engaged.
4. Excessive welding – it increases the cost of welding.
5. When excessive current is used, welding cost also increases.

Welding Terminology

There is some special technical vocabulary (or language) that is used in welding. The basic terms of the welding language include:

Filler Material: When welding two pieces of metal together, we often have to leave a space between the joint. The material that is added to fill this space during the welding process is known as the filler material (or filler metal). Two types of filler metals are commonly used in welding are welding rods and welding electrodes.

- *Welding Rod*: The term welding rod refers to a form of filler metal that does not conduct an electric current during the welding process. The only purpose of a welding rod is to supply filler metal to the joint. This type of filler metal is often used for gas welding.
- *Electrode*: In electric-arc welding, the term electrode refers to the component that conducts the current from the electrode holder to the metal being welded. Electrodes are classified into two groups: consumable and non-consumable.
- *Consumable electrodes* not only provide a path for the current but they also supply filler metal to the joint. An example is the electrode used in shielded metal-arc welding.
- *Non-consumable electrodes* are only used as a conductor for the electrical current, such as in gas tungsten arc welding. The filler metal for gas tungsten arc welding is a hand fed consumable welding rod.

Flux: Before performing any welding process, the base metal must be cleaned form impurities such as oxides (rust). Unless these oxides are removed by using a proper flux, a faulty weld may result. The term *flux* refers to a material used to dissolve oxides and release trapped gases and slag (impurities) from the base metal such that the filler metal and the base metal can be fused together. Fluxes come in the form of a paste, powder, or liquid. Different types of fluxes are available and the selection of appropriate flux is usually based on the type of welding and the type of the base metal.

PHYSICS OF WELDING

Although several coalescing mechanisms are available for welding, fusion is by far the most common means. In this section, we consider the physical relationships that allow fusion welding to be performed. We first examine the issue of power density and its importance, and then we define the heat and power equations that describe a welding process.

POWER DENSITY

To accomplish fusion, a source of high-density heat energy is supplied to the faying surfaces, and the resulting temperatures are sufficient to cause localized melting of the base metals. If a filler metal is added, the heat density must be high enough to melt it also. Heat density can be defined as the power transferred to the work per unit surface area, W/mm^2 ($Btu/sec\text{-}in^2$). The time to melt the metal is inversely proportional to the power density. At low power densities, a significant amount of time is required to cause melting. If power density is too low, the heat is conducted into the work as rapidly as it is added at the surface, and melting never occurs. It has been found that the minimum power density required to melt most metals in welding is about 10 W/mm^2 (6 Btu/sec-in^2). As heat density increases, melting time is reduced. If power density is too high—above around 105 W/mm^2 (60,000 Btu/secin^2) — the localized temperatures vaporize the metal in the affected region. Thus, there is a practical range of values for power density within which welding can be performed. Differences among welding processes in this range are (1) the rate at which welding can be performed and/or (2) the size of the region that can be welded. Table 3 provides a comparison of power densities for the major fusion welding processes. Oxyfuel gas welding is capable of developing large amounts of heat, but the heat density is relatively low because it is spread over a large area. Oxyacetylene gas, the hottest of the OFW fuels, burns at a top temperature of around 3500^{0}C (6300^{0}F). By comparison, arc welding produces high energy over a smaller area, resulting in local temperatures of 5500^{0}C to 6600^{0}C (10,000^{0}F–12,000^{0}F). For metallurgical reasons, it is desirable to melt the metal with minimum energy, and high power densities are generally preferable.

Table 3

Comparison of several fusion welding processes on the basis of their power densities.		
Welding Process	Approximate Power Density W/mm^2	Btu/sec-in^2
Oxyfuel welding	10	6
Arc welding	50	30
Resistanc welding	1000	600
Laser beam welding	9000	5000
Electron beam welding	10000	6000

Power density can be computed as the power entering the surface divided by the corresponding surface area:

$$PD = \frac{P}{A} \text{ ---- } 1$$

Where PD = power density, W/mm^2 (Btu/sec-in2); P = power entering the surface, W (Btu/sec); and A= surface area over which the energy is entering, mm^2 (in^2). The issue is more complicated than indicated by Eq. (1). One complication is that the power source (e.g., the arc) is moving in many welding processes, which results in preheating ahead of the operation and post-heating behind it. Another complication is that power density is not uniform throughout the affected surface; it is distributed as a function of area.

HEAT BALANCE IN FUSION WELDING

The quantity of heat required to melt a given volume of metal depends on (1) the heat to raise the temperature of the solid metal to its melting point, which depends on the metal's volumetric specific heat, (2) the melting point of the metal, and (3) the heat to transform the metal from solid to liquid phase at the melting point, which depends on the metal's heat of fusion. To a reasonable approximation, this quantity of heat can be estimated by the following equation

$$U_m = KT_m^2 \quad .....2$$

Where U_m = the unit energy for melting (i.e., the quantity of heat required to melt a unit volume of metal starting from room temperature), J/mm^3 (Btu/in^3); T_m = melting point of the metal on an absolute temperature scale, ^{0}K (^{0}R); and K= constant whose value is 3.33 x 10^{-6} when the Kelvin scale is used (and K = 1.467 x 10^{-5} for the Rankine temperature scale). Absolute melting temperatures for selected metals are presented in Table 4. Not all of the energy generated at the heat source is used to melt the weld metal. There are two heat transfer mechanisms at work, both of which reduce the amount of generated heat that is used by the welding process. The situation is depicted in Figure 6. The first mechanism involves the transfer of heat between the heat source and the surface of the work. This process has a certain heat transfer factor f_1, defined as the ratio of the actual heat received by the work-piece divided by the total heat generated at the source. The second mechanism involves the conduction of heat away from the weld area to be dissipated throughout the work metal, so that only a portion of the heat transferred to the surface is available for melting. This melting factor f_2 is the proportion of heat received at the work surface that can be used for melting. The combined effect of these two factors is to reduce the heat energy available for welding as follows:

$$H_w = f_1 f_2 H \quad .....3$$

Table 4

Melting temperatures on the absolute temperature scale for selected metals.					
Metal	Melting Temperature ^{0}K^a	^{0}R^b	Metal	Melting Temperature ^{0}K^a	^{0}R^b
Aluminum alloys	930	1680	Steels		
Cast iron	1530	2760	Low carbon	1760	3160
Copper and alloys			Medium carbon	1700	3060
Pure	1350	2440	High carbon	1650	2960
Brass, navy	1160	2090	Low alloy	1700	3060
Bronze (90 Cu–10 Sn)	1120	2010	Stainless steels		
Inconel	1660	3000	Austenitic	1670	3010
Magnesium	940	1700	Martensitic	1700	3060
Nickel	1720	3110	Titanium	2070	3730

[a]Kelvin scale = Centigrade (Celsius) temperature + 273.

[b]Rankine scale = Fahrenheit temperature + 460.

Where H_w = net heat available for welding, J (Btu), f_1 = heat transfer factor, f_2 = the melting factor, and H = the total heat generated by the welding process, J (Btu). The factors f1 and f_2 range in value between zero and one. It is appropriate to separate f_1 and f_2 in concept, even though they act in concert during the welding process. The heat transfer factor f_1 is determined largely by the welding process and the capacity to convert the power source (e.g., electrical energy) into usable heat at the work surface. Arc-welding processes are relatively efficient in this regard, while oxyfuel gas-welding processes are relatively inefficient. The melting factor f_2 depends on the welding process, but it is also influenced by the thermal properties of the metal, joint configuration, and work thickness. Metals with high thermal conductivity, such as aluminum and copper, present a problem in welding because of the rapid dissipation of heat away from the heat contact area. The problem is exacerbated by welding heat sources with low energy densities (e.g., oxyfuel welding) because the heat input is spread over a larger area, thus facilitating conduction into the work. In general, a high power density combined with a low conductivity work material results in a high melting factor. We can now write a balance equation between the energy input and the energy needed for welding:

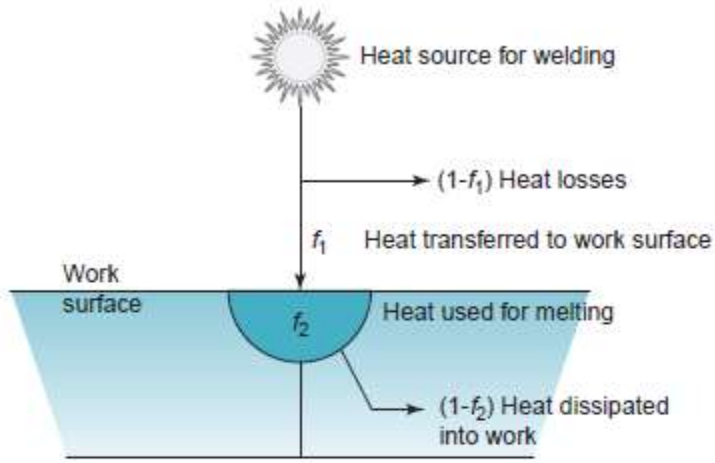


Fig-6. Heat transfer mechanisms in fusion welding.

$$H_w = U_m V \ldots\ldots 4$$

Where H_w = net heat energy used by the welding operation, J (Btu); Um = unit energy required to melt the metal, J/mm^3 (Btu/in^3); and V = the volume of metal melted, mm^3 (in^3). Most welding operations are rate processes; that is, the net heat energy H_w is delivered at a given rate, and the weld bead is made at a certain travel velocity. This is characteristic for example of most arc-welding, many oxyfuel gas-welding operations, and even some resistance welding operations. It is therefore appropriate to express Eq. (A1) as a rate balance equation:

$$R_{Hw} = U_m R_{wv} \ldots\ldots\ldots 5$$

Where R_{Hw} = rate of heat energy delivered to the operation for welding, J/s = W(Btu/min);and R_{WV} = volume rate of metal welded,mm^3/s (in^3/min). In the welding of a continuous bead, the volume rate of metal welded is the product of weld area Aw and travel velocity v. Substituting these terms into the above equation, the rate balance equation can now be expressed as

$$R_{Hw} = f_1 f_2 R_H = U_m A_{wv} \ldots\ldots 6$$

Where f_1 and f_2 are the heat transfer and melting factors; R_H = rate of input energy generated by the welding power source, W (Btu/min); Aw = weld cross-sectional area, mm^2 (in^2); and v = the travel velocity of the welding operation, mm/s (in/min). In previous section, we examine how the power density in Eq. (1) and the input energy rate for Eq. (6) are generated for some of the individual welding processes.

Power Source in Arc Welding.

Both direct current (DC) and alternating current (AC) are used in arc welding. AC machines are less expensive to purchase and operate, but are generally restricted to welding of ferrous metals. DC equipment can be used on all metals with good results and is generally noted for better arc control. In all arc-welding processes, power to drive the operation is the product of the current I passing through the arc and the voltage E across it. This power is converted into heat, but not all of the heat is transferred to the surface of the work. Convection, conduction, radiation, and spatter account for losses that reduce the amount of usable heat. The effect of the losses is expressed by the heat transfer factor f_1 (Physics of welding). Some representative values of f_1 for several AW processes are given in Table 5. Heat transfer factors are

Table 5

Heat transfer factors for several arc-welding processes.	
Arc-Welding Process[a]	Typical Heat Transfer Factor f_1
Shielded metal arc welding	0.9
Gas metal arc welding	0.9
Flux-cored arc welding	0.9
Submerged arc welding	0.95
Gas tungsten arc welding	0.7

greater for AW processes that use consumable electrodes because most of the heat consumed in melting the electrode is subsequently transferred to the work as molten metal. The process with the lowest f_1 value in Table 5 is gas tungsten arc welding, which uses a non-consumable electrode. Melting factor f_2 (Physics of welding) further reduces the available heat for welding. The resulting power balance in arc welding is defined by

$$R_{Hw} = f_1 f_2 IE = U_m A_w v \text{ ..... } 7$$

Where E= voltage, V; I= current, A; and the other terms were defined in Physics of welding. The units of R_{Hw} are watts (current multiplied by voltage), which equal J/sec. This can be converted to Btu/sec by recalling that 1 Btu = 1055 J, and thus 1 Btu/sec = 1055 watts.

OXYFUEL GAS WELDING

Oxyfuel gas welding (OFW) is the term used to describe the group of FW operations that burn various fuels mixed with oxygen to perform welding. The OFW processes employ several types of gases, which is the primary distinction among the members of this group. Oxyfuel gas is also commonly used in cutting torches to cut and separate metal plates and other parts (Section 26.3.5). The most important OFW process is oxyacetylene welding.

OXYACETYLENE WELDING

Oxyacetylene welding (OAW) is a fusion-welding process performed by a high-temperature flame from combustion of acetylene and oxygen. The flame is directed by a welding torch. A filler metal is sometimes added, and pressure is occasionally applied in OAW between the contacting part surfaces. A typical OAW operation is sketched in Figure 7.

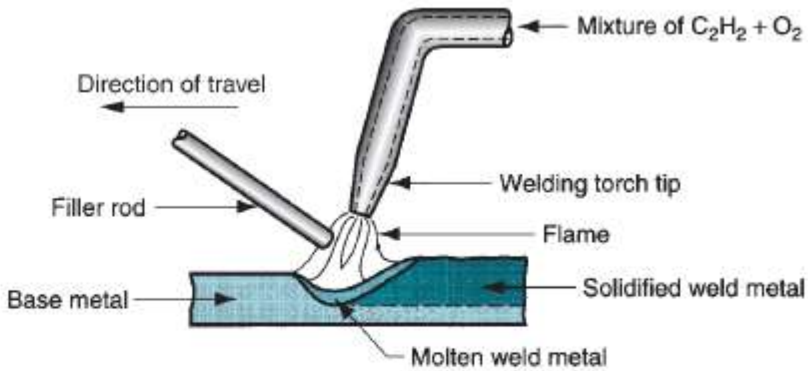


FIGURE 7. A typical oxyacetylene welding operation (OAW).

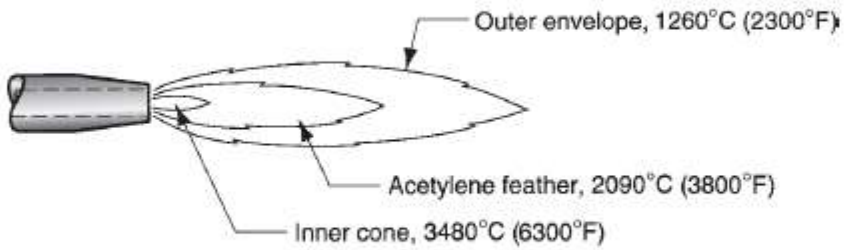


FIGURE 8. The neutral flame from an oxyacetylene torch, indicating temperatures achieved.

When filler metal is used, it is typically in the form of a rod with diameters ranging from1.6 to 9.5mm (1/16–3/8 in). Composition of the filler must be similar to that of the base metals. The filler is often coated with a flux that helps to clean the surfaces and prevent oxidation, thus creating a better weld joint.

Acetylene (C_2H_2) is the most popular fuel among the OFW group because it is capable of higher temperatures than any of the others—up to 3480^0C (6300^0F). The flame in OAW is produced by the chemical reaction of acetylene and oxygen in two stages. The first stage is defined by the reaction

$C_2H_2 + O_2 \rightarrow 2CO \rightarrow H_2 \rightarrow$ heat … 8a

the products of which are both combustible, which leads to the second-stage reaction

$2CO + H_2 + 1{:}5O_2 \rightarrow 2CO_2 + H_2O +$ heat …… 8b

The two stages of combustion are visible in the oxyacetylene flame emitted from the torch. When the mixture of acetylene and oxygen is in the ratio 1:1, as described in Eq. (8), the resulting neutral flame is shown in Figure 8. The first-stage reaction is seen as the inner cone of the flame (which is bright white), while the second-stage reaction is exhibited by the outer envelope (which is nearly colorless but with tinges ranging from blue to orange). The maximum temperature of the flame is reached at the tip of the inner cone; the second-stage temperatures are somewhat below those of the inner cone. During welding, the outer envelope spreads out and covers the work surfaces being joined, thus shielding them from the surrounding atmosphere. Total heat liberated during the two stages of combustion is 55 x 10^6 J/m^3 (1470 Btu/ ft^3) of acetylene. However, because of the temperature distribution in the flame, the way in which the flame spreads over the work surface, and losses to the air, power densities and heat transfer factors in oxyacetylene welding are relatively low; f_1 = 0.10 to 0.30.

The combination of acetylene and oxygen is highly flammable, and the environment in which OAW is performed is therefore hazardous. Some of the dangers relate specifically to the acetylene. Pure C_2H_2 is a colorless, odorless gas. For safety reasons, commercial acetylene is processed to have a characteristic garlic odor. One of the physical limitations of the gas is that it is unstable at pressures much above 1 atm (0.1 MPa or 15 lb/in^2). Accordingly, acetylene storage cylinders are packed with a porous filler material (such as asbestos, balsa wood, and other materials) saturated with acetone (CH_3COCH_3). Acetylene dissolves in liquid acetone; in fact, acetone dissolves about 25 times its own volume of acetylene, thus providing a relatively safe means of storing this welding gas. The welder wears eye and skin protection (goggles, gloves, and protective clothing) as an additional safety precaution, and different screw threads are standard on the acetylene and oxygen cylinders and hoses to avoid accidental connection of the wrong gases. Proper maintenance of the equipment is imperative. OAW equipment is relatively inexpensive and portable. It is therefore an economical, versatile process that is well suited to low-quantity production and repair jobs. It is rarely used to weld sheet and plate stock thicker than 6.4 mm (1/4 in) because of the advantages of arc welding in such applications. Although OAW can be mechanized, it is usually performed manually and is hence dependent on the skill of the welder to produce a high-quality weld joint.

ADVANTAGES AND DISADVANTAGES OF WELDING

Advantages

1. Welding is more economical and is much faster process as compared to other processes (riveting, bolting, casting etc.)
2. Welding, if properly controlled results permanent joints having strength equal or sometimes more than base metal.
3. Large number of metals and alloys both similar and dissimilar can be joined by welding.
4. General welding equipment is not very costly.
5. Portable welding equipments can be easily made available.
6. Welding permits considerable freedom in design.
7. Welding can join welding jobs through spots, as continuous pressure tight seams, end-to-end and in a number of other configurations.
8. Welding can also be mechanized.

Disadvantages

1. It results in residual stresses and distortion of the work-pieces.
2. Welded joint needs stress relieving and heat treatment.
3. Welding gives out harmful radiations (light), fumes and spatter.
4. Jigs, and fixtures may also be needed to hold and position the parts to be welded
5. Edges preparation of the welding jobs are required before welding
6. Skilled welder is required for production of good welding
7. Heat during welding produces metallurgical changes as the structure of the welded joint is not same as that of the parent metal.

Class examples:

1. Estimate the time required for making an open tank of size 40 x 40 x 40cm by gas welding. Size of the sheets used is 50 x 40 x 0.3cm. Welding is to be done on inner surfaces only. Assume fatigue allowance to be 5%.

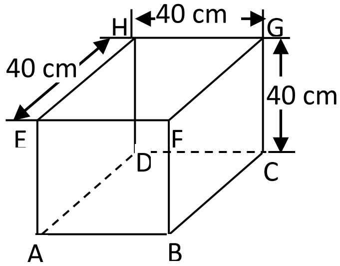


Fig. 1

Solution.

Length of portion where welding is required to be done,

= AB + BC + CD + DA + AE + BF + CG + DH

= 40 x 8 = 320 cm = 3.2m.

As we are required to weld plates of 3mm thickness which is less than 5mm thickness, hence we shall adopt leftward welding technique. From table, welding speed is 12 min/m of welding, for 3mm thick plate. Therefore, time required for making one tank;

= 12 x 3.2 = 38.4 min.

Considering fatigue allowance as 5%,

Actual time taken by welder for welding one tank,

= 38.4 x 1.05 = 40.3 min. ans.

2. Estimate the material cost for welding 2 flat pieces of m.s 15 x 6 x 1cm size, at an angle of 90^0 by gas welding. Neglecting edge preparation cost and assume:

a. cost of O_2 = N10/m^3

b. cost of C_2H_2 = N60/m^3

c. cost of filler metal = N12/kg

d. density of filler metal = 7gm/cc

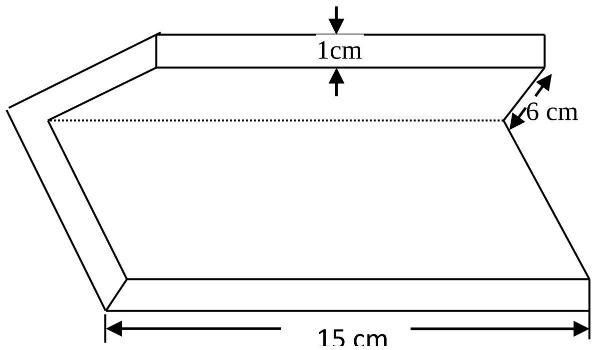


Fig.2

Solution.

As the thickness of the plates to be welded is more than 5mm, therefore, rightward welding method is adopted. From table, 10mm thick plates:

O_2 consumption = 0.7 cu m/hr.

C_2H_2 consumption = 0.5 cum/hr.

Filler rod dia. = 5mm.

Length of filler rod required 4.5m/m of welding.

Welding time = 30min/m of welding.

Therefore, time required to weld 15 cm length-

$\frac{15}{100} \times 30 = 4.5$ min.

1. Amount of O_2 consumed at 0.7 cu m/hr

$= \frac{4.5}{60} \times 0.7 = 0.053$ cu. m.

∴ Cost of O_2 at N10/cu.m = 0.053 x 10 = N0.53.

2. Amount of C_2H_2 consumed in 4.5 min.

at 0.5 cu.m/hr = 0.5 x $\frac{4.5}{60}$ = 0.0375 cu.m

∴ Cost of C_2H_2 = (appro) N60/m^3

= 0.0375 x 60 = N2.25.

3. Length of filler rod required for 15 cm job at 4.5 m/meter welding

= 0.15 x 4.5 = 0.675 m. But for 10mm thick plates, filler rod dia. = 5 mm.

∴ Weight of filler rod consumed = Vol. x Density

$\frac{\pi}{4}(0.5)^2$ x 67.5 x 7 gm =92.8 gm = 0.0928 kg.

∴ Cost of filler rod at N12/kg = 12 x 0.0928 = N1.11.

∴ Total material cost = 0.53 + 2.25 + 1.11 = N3.89. ans.