Texas High School Welding Series

2021-2022
Study Manual

ARC WELDING

TABLE OF CONTENTS

1) ARC WELDING PRINCIPLES
    a) SMAW - Shielded Metal Arc Welding (arc welding or stick welding)
        i) This process is called shielded metal arc welding because of the gaseous cloud formed from the burning of the flux, that forms around the weld
        ii) These gasses help the electrode burn evenly as it mixes with the base metal to remove impurities and prevent oxidation.
    b) Advantages of arc welding
        i) Electricity is a relatively inexpensive way of heating metal
        ii) Most welders suitable for farm and shop work are relatively inexpensive
        iii) Welders are available to work on ordinary 230 volt or 110 household wiring.
        iv) Come in portable engine driven systems
        v) Users can quickly become efficient at this process
    c) Duty Cycle - welding machines get hot during use. This design determines how long it can operate
        i) The duty cycle is the percentage of time that a welder can operate without overheating.
    d) Electricity For Welding
        i) Three basic terms are used to understand how electricity is used for welding; amperes, volts, and watts.
            (1) An ampere (A)or amp is a measure of the rate of flow of current in a conductor.
                (a) Conductor - any material that permits current to move through it.
            (2) A volt (V) or voltage is a measure of electrical pressure.
            (3) A watt (W) or wattage is a measure of energy available for work to be done.
        ii) Here are some equations to help figure how each is calculated.

            $W=V \times A$

$$V = W/A$$

$$A = W/V$$

e) Alternating and Direct Current
    i) Some welders are transformers that receive current directly from utility power lines. Transformers convert high voltage and low amperage to low voltage and high amperage. These are called alternating current welders.
    ii) Alternating Current (AC) is current that reverses its direction of flow frequently.
    iii) Other welders are generators that are engine or motor driven. A generator is a machine that produces direct current.
    iv) Direct Current (DC) flows in one direction only and can be set in accordance with the welder's needs. DC welders can be set for straight or reverse polarity.
    v) Polarity refers to the direction of Flow of electricity in the welding circuit.

2) Welding Equipment
    a) AC Welder - utilize standard 220 volt
    b) DC Welder - driven by motors either; electrical, gasoline or diesel driven.
    c) Welding Cables - used to deliver electricity from the welder to the work. Sizes are denoted in terms of gauge, and can range from size 18 to 0 or lower.
        i) The length of the cable may cause a difference in the welding capabilities. Longer cables may also need to be larger in diameter. If cables are too small they will not deliver as much current as the welder is designed to provide.
    d) Electrode Holder - divide with insulated handles used to grip a welding electrode.
    e) Ground Clamp - spring loaded clamp attached to an electrical cable.
    f) Chipping Hammer - a steel hammer with a sharp edge and or point used to chipp the slag off of welds.

g) Electrode - a specially coated metal rod that conducts electricity from the welder to the metal being welded.

3) Electrodes
    a) Welding electrodes are available to enable a welder to do many different jobs including welding in all positions. Some electrodes are suitable for all positions, some may only be suited for one or two. Much of the difference in electrodes is in the different types of coating on the rods.
    b) The AWS developed a numerical system for coding electrodes, usually a four or five digit number.
    c) Tensile strength is denoted by the first two digits.
        i) Example: E6010 (60) stands for 60,000 pounds per square inch.
    d) Position is denoted by the third number (or fourth if five digit)
        i) Example: E6010 (1) shows to be usable in all positions.
    e) Penetration and or Current is denoted by the fourth number (or fifth in five digit)
        i) Example: E6010 (0) indicates DC reverse polarity only.
    f) Storing Electrodes
        i) If not stored properly, electrodes can corrode and absorb moisture. This is particularly true in humid climates. Moist electrodes will not arc properly and will not produce a quality weld. The best way of storing electrodes is in a storage bin specially designed for electrodes.
4) Safety Procedures
    a) Fire Protection
        i) The temperature of the electric arc creates a very real danger of burns and fires as well.
        ii) Welding booths should be constructed of fireproof or fire-resistant materials such as metal sheets or concrete blocks. Other materials such as pressed wood panels, plywood, and special fire-resistant canvas may also be used.

iii) Fire extinguishers suitable for class A, B, and C fires, safety equipment and first aid kits should be within easy access at all times.

b) Personal Protection

i) No. 10 shade lense must always be worn when welding, but this is to dark to see through except when the arc is burning. Therefore operators must wear safety glasses under the helmet or use a helmet with flip-up lense for processes such as chipping.

ii) Some helmets automatically darken as the light intensifies. Safety classes must still be worn under the helmet.

iii) Fire-resistant coveralls and high leather shoes are recommended as standard clothing when welding.

iv) Leather gloves are needed to protect the hands and wrists from burns. All skin must also be covered to prevent " sunburning".

5) Setting Up

a) When preparing to weld, the appropriate electrode must be selected. For beginners an E6011 or E6013 electrode is a good starting point.

b) Check the welding area to remove all fire hazards.

c) Gather all necessary materials.

d) Check that the machine has suitable welding cables and that they are free of damage.

e) Welder needs to have all the adequate PPE for welding.

f) Machine should be set to the appropriate amperage based on the electrode being used.

g) Then the welder may begin

6) Striking The Arc

a) Before striking an arc, the metal should be placed in a comfortable position on the welding table and clean of grease, oil, or rust.

b) The following Procedure is suggested for striking an arc.

i) Set the proper amperage on the machine and place the electrode in a 90 degree angle in the electrode holder.
ii) Close all curtains in the welding booth
iii) Warn others that you are about to start welding.
iv) Turn on the welder
v) Position the tip of the electrode above the metal and lean it slightly in the direction you plan to move.
    (1) Right handed - move left to right
vi) Drop the face shield or cover lens over your eyes
vii) Strike the arc by quickly lowering, toughing, and lifting the electrode. The lift should only be about an eighth of an inch.
viii) Feed the electrode very slowly as the weld metal burns away, keeping it just above the metal's surface.
ix) Lift the electrode slowly to break the arc after traveling about an inch.
x) Continue practicing these steps until you can start and stop at will.

7) Running Beads
    a) A bead is produced by handling the electrode in a way that results in a proper mix of filler and base metal.
    b) Stringer bead - is a bead made without a weaving pattern
        i) Weaving - means moving the electrode back and forth sideways to create a beat that is wider than the electrode would normally make.
    c) Electrode Angle
        i) Experienced welders vary the angle according to the job. However, beginners are recommended a 75 to 80 degree angle.
    d) Arc length
        i) If the arc length is too long the arc appears unstable
        ii) If the arc is too short, the electrode sticks to the metal
    e) Speed

i) When the speed is a uniform rate, the weld material forms evenly spaced semicircles.
ii) When speed is to fast, the weld material forms V shaped
iii) When speed is too slow the electrode will stick or the weld material may form much wider than the electrode.

f) Amperage
i) If you run the amperage too low it will be difficult to start and stop. The resulting weld will also be stringy in appearance.
ii) If you run the amperage too high the weld puddle will be long and oval shaped. This will also produce lots of splatter
iii) Correct amperage will result in a uniform semicircular weld pattern.

Notes: