UNIT III - ARC WELDING

Gas Tungsten Arc Welding (GTAW) TIG

Objective:

The student will be able to make a series of welds in a variety of positions using gas tungsten arc welding.

Study Questions

1. **What are the principles of GTAW?**

2. **What are the advantages and limitations of GTAW?**

3. **What safety and maintenance considerations need to be observed for GTAW?**

4. **What are the steps for GTAW setup?**

5. **What are the steps for GTAW shutdown?**

References

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8. Demonstration Sheets
   a) DS 3.1: Prewelding and Postwelding Procedures for GTAW

b) DS 3.2: Welds in the Flat Position
c) DS 3.3: Welds in the Horizontal Position
d) DS 3.4: Welds in the Vertical Position
e) DS 3.5: Welds in the Overhead Position

9. Job Sheets
   a) JS 3.1: Prewelding and Postwelding Procedures for GTAW
   b) JS 3.2: Welds in the Flat Position
   c) JS 3.3: Welds in the Horizontal Position
   d) JS 3.4: Welds in the Vertical Position
   e) JS 3.5: Welds in the Overhead Position

UNIT III - ARC WELDING

Gas Tungsten Arc Welding (GTAW) TIG

TEACHING PROCEDURES

A. Review

Review the lesson on gas metal arc welding. Emphasize its application for agricultural use.

B. Motivation

Demonstrate the gas tungsten arc welding process and discuss how it can be applied to agricultural uses. Show students welds that have been made using the GTAW process. Have students compare GTAW joints to those made using other welding methods, such as gas metal arc welding and shielded metal arc welding.

C. Assignment

Upon completion of the written evaluation, students should be ready to complete job sheets 3.1 through 3.5.

D. Supervised Study

E. Discussion

1. What are the principles of GTAW?

Gas tungsten arc welding (GTAW) differs from gas metal arc welding and shielded metal arc welding. How does GTAW work?

a) An electric arc between a nonconsumable tungsten electrode and the base metal produces heat.
b) "Nonconsumable" means that the electrode does not melt and become part of the weld.
c) The arc is shielded by an inert gas, such as argon or helium.
d) Welding can be done with or without filler material. When filler is required, it can be added by dipping a filler rod into the weld pool, by using an automatic feeder, or by placing filler inserts into the weld groove prior to welding.
e) Shielding gas is stored in a cylinder and delivered to the weld by a regulator, a flowmeter, and a torch.
f) The regulator reduces the high storage pressure to a lower working pressure and the flowmeter controls the amount of gas going to the torch.
g) The torch holds the electrode and directs the shielding gas over the weld pool.
h) Torch nozzles are changed depending on the size of the electrode.
i) Torches can be air-cooled or water-cooled to remove heat that can build up during welding.

j) A constant current machine is used for gas tungsten arc welding.
   1) Direct current electrode negative (DCEN, previously called direct current straight polarity or DCSP) produces welds with deep penetration.
   2) Direct current electrode positive (DCEP, previously called direct current reverse polarity or DCRP) produces wide, shallow beads and also has a cleaning effect on some base metals, such as aluminum.
   3) Alternating current (AC) combines the characteristics of DCEN and DCEP and produces welds of medium penetration and has a cleaning effect on some base metals.
   4) Direct current may be steady flowing or pulsed. For pulsed arc GTAW, amperage changes between high or peak current and low or background current. Welding is done during peak current periods, and the weld pool cools during background periods. This reduces heat buildup in the base metal and helps control distortion.

2. What are the advantages and limitations of GTAW?

Ask students to consider the advantages and limitations of the GTAW process. List them on the board and discuss them.

a) Advantages
   1) The gas tungsten process produces an intense and highly concentrated arc heat with a small heat-affected zone around the weld, which means it is less likely to weaken the base metal.
   2) Welds are generally clean. Because GTAW does not use flux, it does not produce slag or residue that can corrode the weld.
   3) Metal is not transferred across the arc, as it is in SMAW, which means there is no spatter.
   4) It produces welds of high quality. Weld chemistry is easily controlled and welds are usually equal to the base metal and stronger and more ductile than welds made by other processes.
   5) The arc and weld pool are clearly visible to the operator because smoke is not produced.
   6) Welding is easily done in all positions.
   7) The process is adaptable to automatic or semi-automatic operations.
   8) It can be used to weld most industrial metals.

b) Limitations
   1) Welding speed is relatively slow.
   2) The cost of the equipment and inert gases and the slower speed make GTAW expensive compared to other processes, such as SMAW.
   3) The intense heat of the arc can cause some erosion of the electrode to occur. The eroded tungsten can travel across the arc to the weld and make it brittle. With practice and experience, the welder can learn to keep tungsten inclusions to a limited, acceptable level.

3. What safety and maintenance considerations need to be observed for GTAW?

Show students a GTAW machine. How does the GTAW machine compare to other welding equipment they have used? Ask students how safety precautions for GTAW are similar and dissimilar to those for other welding equipment. Discuss any additional safety and maintenance considerations as needed.

a) Electrical safety and maintenance
   1) Ensure that the welder is properly grounded.
   2) Inspect all equipment for damage or defect.
   3) Keep all electrical connections tight, clean, and dry.
   4) Keep work area, equipment, and clothing dry.
   5) Never dip a torch in water to cool it.
   6) Disconnect and lock all electrical power sources before performing work on any electrical equipment.
   7) Do not use water to extinguish an electrical fire or any fire near the welder.
   8) When working in high places, check the area for electrical hazards because a shock could cause a fall.
   9) To avoid the risk of shock, do not touch the filler rod to the electrode.
   10) Do not use the power supply above the rated load.
   11) Do not change the current type or current range switch while welding.
b) Safety and maintenance of cables, cylinders, and hoses
   1) Never drag cables or hoses or pull them to force them over an obstruction.
   2) Run hoses and cables so that they will not be damaged or cause a tripping hazard.
   3) Use only clean rags to clean cables and hoses. Never use gas or oily rags to clean cables or hoses.
   4) Keep cables and hoses free of kinks at all times.
   5) Do not drape welding cables or hoses over any type of gas cylinder or over the flowmeter or regulator.
   6) Never strike an arc on a gas cylinder.
   7) Cylinders must be fastened to a wall, post, or approved cylinder truck so that they stay upright at all times.
   8) Valve protection caps should be in place when the cylinder is not in use.
   9) Crack (quickly open and close) cylinders before attaching the regulator to clean any debris out of the cylinder valve outlet. Be sure that the valve is not pointed toward anyone.
c) Personal safety equipment
   1) Wear a welding helmet with a filter lens classified as no. 10 or higher, depending on the work being done. Consult the manufacturer's recommendations for the appropriate lens.
      a. Arc rays can burn both the retina (the back of the eye) and the white of the eye.
      b. Burns to the whites of the eyes are painful and can easily become infected.
      c. Burns to the retina, though not painful, can cause loss of sight.
   2) Wear safety glasses to protect eyes from flying debris.
   3) Wear gloves and high-top leather boots to protect hands and feet. Gloves worn for GTAW are usually thinner than those worn for SMAW or GMAW to give the welder more control over the torch and filler rod.
   4) Wear only wool or cotton clothing that is dark and tightly woven to protect the skin from burns and help block arc rays.
   5) Wear only long-sleeved shirts that button at the sleeves and collar. Keep the sleeves and shirt buttoned, including the top button at the collar.
   6) Wear pants that come down over the top of the boots and do not have cuffs.
   7) Wear any additional protective clothing as needed.

8) Do not wear clothing with torn or frayed areas that could leave the skin exposed or could easily catch fire from sparks.
9) Workstations and work areas should be shielded to prevent an arc flash injury of nearby workers or visitors.
10) Everyone in the work area should wear appropriate eye protection.

e) Work area safety
1) Keep a fire extinguisher, first-aid kit, and safety equipment within easy reach.
2) Follow all procedures for ensuring adequate ventilation and use forced ventilation or respirators when necessary.
a. Gases used in the welding process, such as argon, can displace oxygen and cause dizziness, unconsciousness, or death.
b. Respirators should be worn when welding in confined areas. The respirator should be the air-supplied type or a self-contained breathing apparatus.
c. Every workstation should be equipped with a ventilation or exhaust system capable of safely removing dangerous fumes and vapors.
5) Appropriate ear protection should be worn in areas subject to high noise levels, especially those levels that are continuous.
6) Follow all manufacturer recommendations for solvents and cleaning agents used to clean metal. Failure to do so can result in chemical burns, toxic fumes, or fire hazards.
7) When grinding a tungsten, be sure to keep the palms of the hands clear of the back end of the tungsten in case the grinding wheel suddenly pushes it back or downward.
8) Lighting should be bright enough to provide good visibility free of glare. Poorly lit areas contribute to eye fatigue, irritation, and poor work.

4. What are the steps for GTAW setup?

It is necessary to know how to start and shut down GTAW equipment. Ask students why proper setup is necessary. What problems may result with missed steps?

a) With the power off, attach the torch hoses to the machine.
b) Crack the cylinder valve and attach the flowmeter and regulator to the shielding gas cylinder.
c) Attach the gas hose from the flowmeter to the machine.
d) With the power still off, switch the machine to GTAW, select the type of current, and set the current range.
e) Set the high frequency switch.
f) Set up the remote control.
g) Set the shielding gas postflow timer and adjust the gas flow according to the size of the electrode.
h) Check for proper and complete circulation in the cooling system and verify that there are no leaks.
i) Select the correct size collet body, collet, and nozzle.
j) Select and prepare the tungsten.
k) Adjust electrode extension (the length the electrode extends beyond the nozzle opening).
l) Attach the ground clamp to the base metal.
m) Switch on the machine.

5. What are the steps for GTAW shutdown?

Following the proper shutdown procedure is important for the user's safety and for the life of the equipment. Once students have been introduced to the setup procedure for GTAW, ask them what steps should be followed for shutdown. Use DS 3.1 and JS 3.1.

a) Close the gas cylinder valve. Depress the foot control to bleed the gas line.
b) Shut off the flowmeter, cooling system, and power switch.
c) Remove the electrode from the torch and return it to its proper storage.
d) Remove the collet, collet body, and nozzle and return them to their proper storage.
e) Disconnect the ground clamp.
f) Roll cables neatly. Return any remaining materials and equipment to their proper places.
g) Clean the work area.

F. Other Activities

1. Put together a safety checklist card for GTAW equipment. Distribute copies to students and post a large, easily visible version in the work area.

G. Conclusion

Gas tungsten arc welding uses a nonconsumable tungsten electrode, a shielding gas, and heat from an electric arc to weld. Filler may or may not be used. Gas tungsten arc welding is slower and more expensive than some procedures, but it can produce excellent, slag-free welds on most industrial metals.

H. Competency

Weld in all positions with the gas tungsten arc welder.
a. Weld in flat position
b. Weld in vertical position
c. Weld in horizontal position
d. Weld in overhead position

I. Answers to Evaluation

1. Students should provide four of the following:
   a. The GTAW process produces an intense heat with a small heat-affected zone around the weld, which means it is less likely to weaken the base metal.
   b. Welds are generally clean because GTAW doesn't use flux.
   c. Metal is not transferred across the arc, so no spatter is produced.
   d. It produces a high quality weld. Welds are usually equal to the base metal and stronger and more ductile than welds made by other processes.
   e. The arc and weld pool are clearly visible because smoke is not produced.
   f. Welding is easily done in all positions.
   g. It is adaptable to automatic and semi-automatic operations.

h. It can be used to weld most industrial metals.

2. Students should provide two of the following:

   a. Weld speed is relatively slow.
   b. It is expensive because of the equipment and gas.
   c. The intense heat of the arc can cause some erosion of the electrode. This eroded tungsten can travel across the arc and make welds brittle.

3. An electric arc between a nonconsumable tungsten electrode and the base metal produces heat. The arc is shielded by an inert gas, such as argon or helium, and welding can be done with or without filler.

4. Cracking the cylinder cleans any debris out of the cylinder valve outlet.

5. Good ventilation is necessary to prevent the accumulation of dangerous fumes and vapors. Gases used in the welding process, such as argon, can displace oxygen and cause dizziness, unconsciousness, or death.

6. Arc rays can burn the retina and the white of the eye. Burns to the whites of the eyes are painful and can easily become infected. Burns to the retina can cause loss of sight.

7. d

8. c

UNIT III - ARC WELDING

Gas Tungsten Arc Welding Name_____

(GTAW) / TIG Date_____

EVALUATION

Complete the following short answer questions.

1. Name four advantages of GTAW.

   a.

   b.

   c.

   d.

2. Name two limitations of GTAW.

   a.

   b.

3. How is a GTAW weld made?

4. What is the purpose of cracking a gas cylinder?

5. Why should a welding area be well ventilated?

6. Why is a helmet with a filter lens needed for welding?

Circle the letter that corresponds to the best answer.

7. Which of the following is a step in setting up a gas tungsten arc welder?

   a. Disconnect the ground clamp.

   b. Drape the hoses over the gas cylinder.

   c. Dip the torch in water.

   d. Attach the flowmeter and regulator.

8. Which of the following is a step in shutting down a gas tungsten arc welder?

   a. Set shielding gas postflow.

   b. Attach hoses with the power off.

   c. Clean the work area.

   d. Prepare the tungsten.

UNIT III - ARC WELDING

Demonstration Sheet 3.1: Prewelding and Postwelding Procedures for GTAW

Objective

At the completion of this demonstration, the student will be prepared to begin the job sheet in setting up, adjusting, and shutting down the gas tungsten arc welding machine.

Tools and Equipment Needed

1. GTAW machine and accessories
2. Protective clothing
3. Safety goggles*
4. Helmet
5. Adjustable wrench or appropriate open-end wrench
6. Shielding gas cylinder
7. Tungsten
8. Pliers

* CAUTION: Everyone participating in or observing the demonstration should wear appropriate protective eyewear. Safety precautions should be observed while in the shop area.

Materials Needed

1. Metal plates - type and size to be determined by the instructor
2. Filler metal - per instructor

Prewelding Procedures

1. With the power off, attach the torch hoses to the machine.
2. Check that the gas cylinder is safely secured in an upright position. Remove the cylinder cap. Crack the cylinder to clear the cylinder valve fitting.
3. Attach the flowmeter and regulator to the cylinder valve. Tighten the regulator fitting nut with the wrench, but do not overtighten.
4. Attach the gas hose from the flowmeter to the machine.
5. With the power still off, switch the machine to GTAW, select the type of current, and set the current range according to metal thickness.
6. Set the high frequency switch.
7. Set the spark control for soft start. Set up the remote control, depending on the machine's accessories.
8. Set the shielding gas postflow timer according to electrode size.
9. Check to be sure that the flowmeter adjusting valve is shut off. If it isn't, turn it clockwise until it is tight.

10. Stand to one side and turn on the cylinder valve.
11. Adjust gas flow according to the size of the electrode.
12. Check for proper and complete circulation in the cooling system and verify that there are no leaks.
13. Select the correct size collet body, collet, and nozzle according to the electrode size.
14. Select and prepare the tungsten.
15. Adjust electrode extension (the length the electrode extends beyond the nozzle opening).
16. Attach the ground clamp to the base metal.
17. Switch on the machine.
18. Position the base metal and hold the torch with the dominant hand. Move the torch so that the nozzle rests on the metal with the electrode about 3/16 in. off the surface.
19. Cover up and remind others in the area to do so as well. Depress the foot control until an arc jumps the gap. Correct the electrode angle as soon as the arc is established.
20. Preheat the starting point until a small molten puddle is formed.
    Move the filler rod into the leading edge of the molten puddle and let a drop or two of molten filler metal fill the puddle.
21. Withdraw the filler rod about 1/2 in. from the arc so the torch and puddle can be moved in the direction of travel; be sure to keep the end of the rod in the shielded area.
22. Move the puddle forward while using the torch to maintain a uniform bead width, then reinsert the filler rod into the center of the molten puddle at the point of the arc, letting a drop or two of filler metal fill the puddle.
23. Repeat the procedure until the stringer bead is completed.
24. Stop at the edge of the plate and release the foot control. Keep the torch in place for a few seconds after the weld is completed.
25. Shut down the welding machine.
26. Explain any additional features of your gas tungsten arc welding machine.

Postwelding Procedure

1. When welding is complete, close the gas cylinder valve. Depress the foot control to bleed the gas line.
2. Shut off the flowmeter, cooling system, and power switch.
3. Remove the electrode from the torch and return it to its proper storage.
4. Remove the collet, collet body, and nozzle and return them to their proper storage.
5. Disconnect the ground clamp.
6. Roll cables neatly. Return any remaining materials and equipment to their proper places.
7. Clean the work area.

UNIT III - ARC WELDING

Demonstration Sheet 3.2: Welds in the Flat Position

Objective

At the completion of the demonstration, the student will be prepared to begin the job sheet in performing butt, lap, and T-fillet welds in the flat position using a GTAW welder.

Tools and Equipment Needed

1. GTAW machine and accessories
2. Protective clothing
3. Safety goggles*
4. Helmet
5. Adjustable wrench or appropriate open-end wrench
6. Shielding gas cylinder
7. Tungsten
8. Pliers

* CAUTION: Everyone participating in or observing the demonstration should wear appropriate protective eyewear. Safety precautions must be observed while in the shop area.

Materials Needed

1. Filler metal - per instructor
2. Mild steel plates - size to be determined by the instructor

Prewelding Procedure

Refer to DS 3.1 for prewelding procedures.

Welding Procedure

BUTT JOINT

1. Lower the helmet. Tack weld two pieces of mild steel together to form a butt joint. “Cover” should be said before striking an arc. If the metal is thicker than 1/8 inch, the edges of the joint should be beveled to increase penetration. A space, approximately 1/16 inch, should be left between the metal plates to increase penetration of the weld.
2. Position the metal so that the joint to be welded will be in flat position.
3. The electrode should be perpendicular to the surface of the weld and pointed forward with the torch approximately 70 to 80 degrees from the weld axis. The filler rod is held at a 15 to 20 degree angle to the plate.
4. Lower the helmet and strike the arc.

5. Move the filler rod into the leading edge of the molten puddle and let a drop or two of molten filler metal fill the puddle.
6. Withdraw the filler rod about 1/2 inch from the arc so the torch and puddle can be moved in the direction of travel; be sure to keep the end of the rod in the shielded area.
7. Advance the puddle while using the torch to maintain a uniform bead width. Then reinsert the filler rod into the center of the molten puddle at the point of the arc; let a drop or two of molten filler metal fill the puddle.
8. Repeat the procedure until the weld is complete.
9. Stop just as you reach the end of the plate and let off the foot control. Keep the torch in place for a few seconds after the end of the weld.
10. Examine the weld for penetration and bead appearance.
11. Discuss possible improvements with students and how these improvements might be accomplished.

LAP JOINT

1. Lower the helmet. Tack weld two pieces of mild steel together to form a lap joint. "Cover" should be said before striking an arc.
2. Position the metal so that the joint to be welded will be in flat position.
3. The electrode should be held at a 45 degree angle to the surface of the weld and pointed forward at approximately 70 to 80 degrees from the weld axis. The filler rod is held at a 15 to 20 degree angle to the plate.
4. Lower the helmet and strike the arc.
5. Move the filler rod into the leading edge of the molten puddle and let a drop or two of molten filler metal fill the puddle.
6. Withdraw the filler rod about 1/2 inch from the arc so the torch and puddle can be moved in the direction of travel; be sure to keep the end of the rod in the shielded area.
7. Advance the puddle while using the torch to maintain a uniform bead width. Then reinsert the filler rod into the center of the molten puddle at the point of the arc; let a drop or two of molten filler metal fill the puddle.
8. Repeat the procedure until the weld is complete.
9. Stop just as you reach the end of the plate and let off the foot control. Keep the torch in place for a few seconds after the end of the weld.
10. Examine the weld for penetration and bead appearance.
11. Discuss possible improvements with students and how these improvements might be accomplished.

T-FILLET JOINT

1. Lower the helmet. Tack weld two pieces of mild steel together to form a T joint. "Cover" should be said before striking an arc.
2. Position the metal so that the joint to be welded will be in flat position.
3. The electrode should be held at a 45 degree angle to the surface of the weld and pointed forward at approximately 70 to 80 degrees from the weld axis. The filler rod is held at a 15 to 20 degree angle to the plate.
4. Lower the helmet and strike the arc.
5. Move the filler rod into the leading edge of the molten puddle and let a drop or two of molten filler metal fill the puddle.
6. Withdraw the filler rod about 1/2 inch from the arc so the torch and puddle can be moved in the direction of travel; be sure to keep the end of the rod in the shielded area.

7. Advance the puddle while using the torch to maintain a uniform bead width. Then reinsert the filler rod into the center of the molten puddle at the point of the arc; let a drop or two of molten filler metal fill the puddle.
8. Repeat the procedure until the weld is complete.
9. Stop just as you reach the end of the plate and let off the foot control. Keep the torch in place for a few seconds after the end of the weld.
10. Examine the weld for penetration and bead appearance.
11. Discuss possible improvements with students and how these improvements might be accomplished.

Postwelding Procedure

Refer to DS 3.1 for postwelding procedures.

UNIT III -ARC WELDING

Demonstration Sheet 3.3: Welds in the Horizontal Position

Objective

At the completion of this demonstration, the student will be ready to begin the job sheet in performing butt, lap, and T-fillet welds in the horizontal position using a GTAW welder.

Tools and Equipment Needed

1. GTAW machine and accessories
2. Protective clothing
3. Safety goggles*
4. Helmet
5. Adjustable wrench or appropriate open-end wrench
6. Shielding gas cylinder
7. Tungsten
8. Pliers

* CAUTION: Everyone participating in or observing the demonstration should wear appropriate protective eyewear. Safety precautions must be observed while in the shop area.

Materials Needed

1. Filler metal - per instructor
2. Mild steel plates - size to be determined by the instructor

Prewelding Procedure

Refer to DS 3.1 for prewelding procedures needed to prepare for horizontal position welding.

Welding Procedure

BUTT JOINT

1. Lower the helmet. Tack weld two pieces of mild steel together to form a butt joint. “Cover” should be said before striking an arc. If the metal is thicker than 1/8 inch, the edges of the joint should be beveled to increase penetration. A space, approximately 1/16 inch, should be left between the metal plates to increase penetration of the weld.
2. Position the metal so that the joint to be welded will be in the horizontal position.
3. The torch should be held 75 to 80 degrees to the surface of the weld and the back of the torch should be tipped downward so that the electrode is pointing up toward the weld at a 15 degree angle. The filler rod is held at a 20 degree angle to the plate.
4. Lower the helmet and strike the arc.

5. Move the filler rod into the leading edge of the molten puddle and let a drop or two of molten filler metal fill the puddle.
6. Withdraw the filler rod about 1/2 inch from the arc so the torch and puddle can be moved in the direction of travel; be sure to keep the end of the rod in the shielded area.
7. Advance the puddle while using the torch to maintain a uniform bead width. Then reinsert the filler rod into the center of the molten puddle at the point of the arc; let a drop or two of molten filler metal fill the puddle.
8. Repeat the procedure until the weld is complete.
9. Stop just as you reach the end of the plate and let off the foot control. Keep the torch in place for a few seconds after the end of the weld.
10. Examine the weld for penetration and bead appearance.
11. Discuss possible improvements with students and how these improvements might be accomplished.

LAP JOINT

1. Lower the helmet. Tack weld two pieces of mild steel together to form a lap joint. "Cover" should be said before striking an arc.
2. Position the metal so that the joint to be welded will be in the horizontal position.
3. The electrode should be held 45 degrees to the surface of the weld and pointed forward at 70 to 80 degrees from the weld axis. The filler rod is held at a 20 degree angle to the plate.
4. Lower the helmet and strike the arc.
5. Move the filler rod into the leading edge of the molten puddle and let a drop or two of molten filler metal fill the puddle.
6. Withdraw the filler rod about 1/2 inch from the arc so the torch and puddle can be moved in the direction of travel; be sure to keep the end of the rod in the shielded area.
7. Advance the puddle while using the torch to maintain a uniform bead width. Then reinsert the filler rod into the center of the molten puddle at the point of the arc; let a drop or two of molten filler metal fill the puddle.
8. Repeat the procedure until the weld is complete.
9. Stop just as you reach the end of the plate and let off the foot control. Keep the torch in place for a few seconds after the end of the weld.
10. Examine the weld for penetration and bead appearance.
11. Discuss possible improvements with students and how these improvements might be accomplished.

T-FILLET JOINT

1. Lower the helmet. Tack weld two pieces of mild steel together to form a T joint. "Cover" should be said before striking an arc.
2. Position the metal so that the joint to be welded will be in the horizontal position.
3. The electrode should be held 45 degrees to the surface of the weld and pointed forward at 70 to 80 degrees from the weld axis. The filler rod is held at a 15 to 20 degree angle to the plate.
4. Lower the helmet and strike the arc.
5. Move the filler rod into the leading edge of the molten puddle and let a drop or two of molten filler metal fill the puddle.
6. Withdraw the filler rod about 1/2 inch from the arc so the torch and puddle can be moved in the direction of travel; be sure to keep the end of the rod in the shielded area.

7. Advance the puddle while using the torch to maintain a uniform bead width. Then reinsert the filler rod into the center of the molten puddle at the point of the arc; let a drop or two of molten filler metal fill the puddle.
8. Repeat the procedure until the weld is complete.
9. Stop just as you reach the end of the plate and let off the foot control. Keep the torch in place for a few seconds after the end of the weld.
10. Examine the weld for penetration and bead appearance.
11. Discuss possible improvements with students and how these improvements might be accomplished.

Postwelding Procedure

Refer to DS 3.1 for postwelding procedures.

UNIT III - ARC WELDING

Demonstration Sheet 3.4: Welds in the Vertical Position

Objective

At the completion of this demonstration, the student will be ready to begin the job sheet in performing butt, lap, and T-fillet welds in the vertical position using a GTAW welder.

Tools and Equipment Needed

1. GTAW machine and accessories
2. Protective clothing
3. Safety goggles*
4. Helmet
5. Adjustable wrench or appropriate open-end wrench
6. Shielding gas cylinder
7. Tungsten
8. Pliers

* CAUTION: Everyone participating in or observing the demonstration should wear appropriate protective eyewear. Safety precautions must be observed while in the shop area.

Materials Needed

1. Filler metal - per instructor
2. Mild steel plates - size to be determined by the instructor

Prewelding Procedure

Refer to DS 3.1 for prewelding procedures.

Welding Procedure

BUTT JOINT

1. Lower the helmet. Tack weld two pieces of mild steel together to form a butt joint. "Cover" should be said before striking an arc. If the metal is thicker than 1/8 inch, the edges of the joint should be beveled to increase penetration. A space, approximately 1/16 inch, should be left between the metal plates to increase penetration of the weld.
2. Position the metal so that the joint to be welded will be in the vertical position. For thicker metal, it is best to weld with the weld pool moving from the bottom to the top, or vertically up. For thinner metal, it is best to weld with the pool moving from the top to the bottom, or vertically down.
3. The torch should be held perpendicular to the surface of the weld and tipped down so that the torch is 75 to 80 degrees from the base metal. The filler rod is held at an angle of approximately 35 to 45 degrees to the plate.

4. Lower the helmet and strike the arc.
5. Move the filler rod into the leading edge of the molten puddle and let a drop or two of molten filler metal fill the puddle.
6. Withdraw the filler rod about 1/2 inch from the arc so the torch and puddle can be moved in the direction of travel; be sure to keep the end of the rod in the shielded area.
7. Advance the puddle while using the torch to maintain a uniform bead width. Then reinsert the filler rod into the center of the molten puddle at the point of the arc; let a drop or two of molten filler metal fill the puddle.
8. Repeat the procedure until the weld is complete.
9. Stop just as you reach the end of the plate and let off the foot control. Keep the torch in place for a few seconds after the end of the weld.
10. Examine the weld for penetration and bead appearance.
11. Discuss possible improvements with students and how these improvements might be accomplished.

LAP JOINT

1. Lower the helmet. Tack weld two pieces of mild steel together to form a lap joint. "Cover" should be said before striking an arc.
2. Position the metal so that the joint to be welded will be in the vertical position. For thicker metal, it is best to weld with the weld pool moving from the bottom to the top, or vertically up. For thinner metal, it is best to weld with the pool moving from the top to the bottom, or vertically down.
3. The torch should be centered over the root of the weld and tipped down so that the torch is 75 to 80 degrees from the base metal. The filler rod is held at an angle of approximately 35 to 45 degrees to the plate.
4. Lower the helmet and strike the arc.
5. Move the filler rod into the leading edge of the molten puddle and let a drop or two of molten filler metal fill the puddle.
6. Withdraw the filler rod about 1/2 inch from the arc so the torch and puddle can be moved in the direction of travel; be sure to keep the end of the rod in the shielded area.
7. Advance the puddle while using the torch to maintain a uniform bead width. Then reinsert the filler rod into the center of the molten puddle at the point of the arc; let a drop or two of molten filler metal fill the puddle.
8. Repeat the procedure until the weld is complete.
9. Stop just as you reach the end of the plate and let off the foot control. Keep the torch in place for a few seconds after the end of the weld.
10. Examine the weld for penetration and bead appearance.
11. Discuss possible improvements with students and how these improvements might be accomplished.

T-FILLET JOINT

1. Lower the helmet. Tack weld two pieces of mild steel together to form a T joint. "Cover" should be said before striking an arc.
2. Position the metal so that the joint to be welded will be in the vertical position. For thicker metal, it is best to weld with the weld pool moving from the bottom to the top, or vertically up. For thinner metal, it is best to weld with the pool moving from the top to the bottom, or vertically down.
3. The torch should be centered over the root of the weld and tipped down so that the torch is 75 to 80 degrees from the base metal. The filler rod is held at an angle of approximately 35 to 45 degrees to the plate.

4. Lower the helmet and strike the arc.
5. Move the filler rod into the leading edge of the molten puddle and let a drop or two of molten filler metal fill the puddle.
6. Withdraw the filler rod about 1/2 inch from the arc so the torch and puddle can be moved in the direction of travel; be sure to keep the end of the rod in the shielded area.
7. Advance the puddle while using the torch to maintain a uniform bead width. Then reinsert the filler rod into the center of the molten puddle at the point of the arc; let a drop or two of molten filler metal fill the puddle.
8. Repeat the procedure until the weld is complete.
9. Stop just as you reach the end of the plate and let off the foot control. Keep the torch in place for a few seconds after the end of the weld.
10. Examine the weld for penetration and bead appearance.
11. Discuss possible improvements with students and how these improvements might be accomplished.

Postwelding Procedure

Refer to DS 3.1 for postwelding procedures.

UNIT III -ARC WELDING

Demonstration Sheet 3.5: Welds in the Overhead Position

Objective

At the completion of this demonstration, the student will be ready to begin the shop exercise in performing butt, lap, and T-fillet weld in the overhead position using a GTAW welder.

Tools and Equipment Needed

1. GTAW machine and accessories
2. Protective clothing
3. Safety goggles*
4. Helmet
5. Adjustable wrench or appropriate open-end wrench
6. Shielding gas cylinder
7. Tungsten
8. Pliers

* CAUTION: Everyone participating in or observing the demonstration should wear appropriate protective eyewear. Safety precautions must be observed while in the shop area.

Materials Needed

1. Filler metal - per instructor
2. Mild steel plates - size to be determined by the instructor

Prewelding Procedure

Refer to DS 3.1 for prewelding procedures.

Welding Procedure

BUTT JOINT

1. Lower the helmet. Tack weld two pieces of mild steel together to form a butt joint. “Cover” should be said before striking an arc. If the metal is thicker than 1/8 inch, the edges of the joint should be beveled to increase penetration. A space, approximately 1/16 inch, should be left between the metal plates to increase penetration of the weld.
2. Position the metal so that the joint to be welded will be in the overhead position.
3. The electrode should be perpendicular to the surface of the weld and pointed forward with the torch approximately 70 to 80 degrees from the weld axis. The filler rod is held at a 15 to 20 degree angle to the plate.
4. Lower the helmet and strike the arc.

5. Move the filler rod into the leading edge of the molten puddle and let a drop or two of molten filler metal fill the puddle.
6. Withdraw the filler rod about 1/2 inch from the arc so the torch and puddle can be moved in the direction of travel; be sure to keep the end of the rod in the shielded area.
7. Advance the puddle while using the torch to maintain a uniform bead width. Then reinsert the filler rod into the center of the molten puddle at the point of the arc; let a drop or two of molten filler metal fill the puddle.
8. Repeat the procedure until the weld is complete.
9. Stop just as you reach the end of the plate and let off the foot control. Keep the torch in place for a few seconds after the end of the weld.
10. Examine the weld for penetration and bead appearance.
11. Discuss possible improvements with students and how these improvements might be accomplished.

LAP JOINT

1. Lower the helmet. Tack weld two pieces of mild steel together to form a lap joint. "Cover" should be said before striking an arc.
2. Position the metal so that the joint to be welded will be in the overhead position.
3. The electrode should be held at a 45 degree angle to the surface of the weld and pointed forward at approximately 70 to 80 degrees from the weld axis. The filler rod is held at a 15 to 20 degree angle to the plate.
4. Lower the helmet and strike the arc.
5. Move the filler rod into the leading edge of the molten puddle and let a drop or two of molten filler metal fill the puddle.
6. Withdraw the filler rod about 1/2 inch from the arc so the torch and puddle can be moved in the direction of travel; be sure to keep the end of the rod in the shielded area.
7. Advance the puddle while using the torch to maintain a uniform bead width. Then reinsert the filler rod into the center of the molten puddle at the point of the arc; let a drop or two of molten filler metal fill the puddle.
8. Repeat the procedure until the weld is complete.
9. Stop just as you reach the end of the plate and let off the foot control. Keep the torch in place for a few seconds after the end of the weld.
10. Examine the weld for penetration and bead appearance.
11. Discuss possible improvements with students and how these improvements might be accomplished.

T-FILLET JOINT

1. Lower the helmet. Tack weld two pieces of mild steel together to form a T joint. "Cover" should be said before striking an arc.
2. Position the metal so that the joint to be welded will be in the overhead position.
3. The electrode should be held at a 45 degree angle to the surface of the weld and pointed forward at approximately 70 to 80 degrees from the weld axis. The filler rod is held at a 15 to 20 degree angle to the plate.
4. Lower the helmet and strike the arc.
5. Move the filler rod into the leading edge of the molten puddle and let a drop or two of molten filler metal fill the puddle.
6. Withdraw the filler rod about 1/2 inch from the arc so the torch and puddle can be moved in the direction of travel; be sure to keep the end of the rod in the shielded area.

7. Advance the puddle while using the torch to maintain a uniform bead width. Then reinsert the filler rod into the center of the molten puddle at the point of the arc; let a drop or two of molten filler metal fill the puddle.
8. Repeat the procedure until the weld is complete.
9. Stop just as you reach the end of the plate and let off the foot control. Keep the torch in place for a few seconds after the end of the weld.
10. Examine the weld for penetration and bead appearance.
11. Discuss possible improvements with students and how these improvements might be accomplished.

Postwelding Procedure

Refer to DS 3.1 for postwelding procedures.

UNIT III - ARC WELDING

Job Sheet 3.1: Prewelding and Postwelding Procedures for GTAW

Objective

At the completion of this job sheet, the student will be able to set up, adjust, and shut down the machine used for gas tungsten arc welding.

Tools and Equipment Needed

1. GTAW machine and accessories
2. Protective clothing
3. Safety goggles*
4. Helmet
5. Adjustable wrench or appropriate open-end wrench
6. Shielding gas cylinder
7. Tungsten
8. Pliers

* CAUTION: Everyone participating in or observing this procedure should wear appropriate protective eyewear. Safety precautions should be observed while in the shop area.

Materials Needed

1. Metal plates - type and size to be determined by the instructor
2. Filler metal - per instructor

Prewelding Procedures

1. Be sure all equipment is in safe working condition and that proper safety precautions are followed at all times.
2. With the power off, attach the torch hoses to the machine.
3. Check that the gas cylinder is safely secured in an upright position. Remove the cylinder cap. Crack the cylinder to clear the cylinder valve fitting.
4. Attach the flowmeter and regulator to the cylinder valve. Tighten the regulator fitting nut with the wrench, but do not overtighten.
5. Attach the gas hose from the flowmeter to the machine.
6. With the power still off, switch the machine to GTAW, select the type of current, and set the current range according to metal thickness.
7. Set the high frequency switch.
8. Set the spark control for soft start. Set up the remote control, depending on the machine's accessories.
9. Set the shielding gas postflow timer according to electrode size.

10. Check to be sure that the flowmeter adjusting valve is shut off. If it isn't, turn it clockwise until it is tight.
11. Stand to one side and turn on the cylinder valve.
12. Adjust gas flow according to the size of the electrode.
13. Check for proper and complete circulation in the cooling system and verify that there are no leaks.
14. Select the correct size collet body, collet, and nozzle according to the electrode size.
15. Select and prepare the tungsten.
16. Adjust electrode extension (the length the electrode extends beyond the nozzle opening).
17. Attach the ground clamp to the base metal.
18. Switch on the machine.
19. Position the base metal and hold the torch with the dominant hand. Move the torch so that the nozzle rests on the metal with the electrode about 3/16 in. off the surface.
20. Cover up and remind others in the area to do so as well. Depress the foot control until an arc jumps the gap. Correct the electrode angle as soon as the arc is established.
21. Preheat the starting point until a small molten puddle is formed.
    Move the filler rod into the leading edge of the molten puddle and let a drop or two of molten filler metal fill the puddle.
22. Withdraw the filler rod about 1/2 in. from the arc so the torch and puddle can be moved in the direction of travel; be sure to keep the end of the rod in the shielded area.
23. Move the puddle forward while using the torch to maintain a uniform bead width, then reinsert the filler rod into the center of the molten puddle at the point of the arc, letting a drop or two of filler metal fill the puddle.
24. Repeat the procedure until the stringer bead is completed.
25. Stop at the edge of the plate and release the foot control. Keep the torch in place for a few seconds after the weld is completed.
26. Ask the instructor to check the results of the procedure.

Postwelding Procedure

1. When welding is complete, close the gas cylinder valve. Depress the foot control to bleed the gas line.
2. Shut off the flowmeter, cooling system, and power switch.
3. Remove the electrode from the torch and return it to its proper storage.
4. Remove the collet, collet body, and nozzle and return them to their proper storage.
5. Disconnect the ground clamp.
6. Roll cables neatly. Return any remaining materials and equipment to their proper places.
7. Clean the work area.
8. Ask the instructor to check the results of the procedure.

UNIT III - ARC WELDING

Job Sheet 3.2: Welds in the Flat Position

Objective

At the completion of this job sheet, the student will be able to perform butt, lap, and T-fillet welds in the flat position using a GTAW welder.

Tools and Equipment Needed

1. GTAW machine and accessories
2. Protective clothing
3. Safety goggles*
4. Helmet
5. Adjustable wrench or appropriate open-end wrench
6. Shielding gas cylinder
7. Tungsten
8. Pliers

* CAUTION: Everyone participating in or observing the procedure should wear appropriate protective eyewear. Safety precautions must be observed while in the shop area.

Materials Needed

1. Filler metal - per instructor
2. Mild steel plates - size to be determined by the instructor

Prewelding Procedure

Refer to JS 3.1 for prewelding procedures.

Welding Procedure

BUTT JOINT

1. Lower the helmet. Tack weld two pieces of mild steel together to form a butt joint. "Cover" should be said before striking an arc. If the metal is thicker than 1/8 inch, the edges of the joint should be beveled to increase penetration. A space, approximately 1/16 inch, should be left between the metal plates to increase penetration of the weld.
2. Position the metal so that the joint to be welded will be in flat position.
3. The electrode should be perpendicular to the surface of the weld and pointed forward with the torch approximately 70 to 80 degrees from the weld axis. The filler rod is held at a 15 to 20 degree angle to the plate.
4. Lower the helmet and strike the arc.

5. Move the filler rod into the leading edge of the molten puddle and let a drop or two of molten filler metal fill the puddle.
6. Withdraw the filler rod about 1/2 inch from the arc so the torch and puddle can be moved in the direction of travel; be sure to keep the end of the rod in the shielded area.
7. Advance the puddle while using the torch to maintain a uniform bead width. Then reinsert the filler rod into the center of the molten puddle at the point of the arc; let a drop or two of molten filler metal fill the puddle.
8. Repeat the procedure until the weld is complete.
9. Stop just as you reach the end of the plate and let off the foot control. Keep the torch in place for a few seconds after the end of the weld.
10. Examine the weld for penetration and bead appearance.
11. Turn in the weld to the instructor for grading.

LAP JOINT

1. Lower the helmet. Tack weld two pieces of mild steel together to form a lap joint. "Cover" should be said before striking an arc.
2. Position the metal so that the joint to be welded will be in flat position.
3. The electrode should be held at a 45 degree angle to the surface of the weld and pointed forward at approximately 70 to 80 degrees from the weld axis. The filler rod is held at a 15 to 20 degree angle to the plate.
4. Lower the helmet and strike the arc.
5. Move the filler rod into the leading edge of the molten puddle and let a drop or two of molten filler metal fill the puddle.
6. Withdraw the filler rod about 1/2 inch from the arc so the torch and puddle can be moved in the direction of travel; be sure to keep the end of the rod in the shielded area.
7. Advance the puddle while using the torch to maintain a uniform bead width. Then reinsert the filler rod into the center of the molten puddle at the point of the arc; let a drop or two of molten filler metal fill the puddle.
8. Repeat the procedure until the weld is complete.
9. Stop just as you reach the end of the plate and let off the foot control. Keep the torch in place for a few seconds after the end of the weld.
10. Examine the weld for penetration and bead appearance.
11. Turn in the weld to the instructor for grading.

T-FILLET JOINT

1. Lower the helmet. Tack weld two pieces of mild steel together to form a T joint. "Cover" should be said before striking an arc.
2. Position the metal so that the joint to be welded will be in flat position.
3. The electrode should be held at a 45 degree angle to the surface of the weld and pointed forward at approximately 70 to 80 degrees from the weld axis. The filler rod is held at a 15 to 20 degree angle to the plate.
4. Lower the helmet and strike the arc.
5. Move the filler rod into the leading edge of the molten puddle and let a drop or two of molten filler metal fill the puddle.
6. Withdraw the filler rod about 1/2 inch from the arc so the torch and puddle can be moved in the direction of travel; be sure to keep the end of the rod in the shielded area.

7. Advance the puddle while using the torch to maintain a uniform bead width. Then reinsert the filler rod into the center of the molten puddle at the point of the arc; let a drop or two of molten filler metal fill the puddle.
8. Repeat the procedure until the weld is complete.
9. Stop just as you reach the end of the plate and let off the foot control. Keep the torch in place for a few seconds after the end of the weld.
10. Examine the weld for penetration and bead appearance.
11. Turn in the weld to the instructor for grading.

Postwelding Procedure

Refer to JS 3.1 for postwelding procedures.

UNIT III -ARC WELDING

Job Sheet 3.3: Welds in the Horizontal Position

Objective

At the completion of this job sheet, the student will be able to perform a butt, lap, and T-fillet weld in the horizontal position using a GTAW welder.

Tools and Equipment Needed

1. GTAW machine and accessories
2. Protective clothing
3. Safety goggles*
4. Helmet
5. Adjustable wrench or appropriate open-end wrench
6. Shielding gas cylinder
7. Tungsten
8. Pliers

* CAUTION: Everyone participating in or observing the procedure should wear appropriate protective eyewear. Safety precautions must be observed while in the shop area.

Materials Needed

1. Filler metal - per instructor
2. Mild steel plates - size to be determined by the instructor

Prewelding Procedure

Refer to JS 3.1 for prewelding procedures needed to prepare for horizontal position welding.

Welding Procedure

BUTT JOINT

1. Lower the helmet. Tack weld two pieces of mild steel together to form a butt joint. "Cover" should be said before striking an arc. If the metal is thicker than 1/8 inch, the edges of the joint should be beveled to increase penetration. A space, approximately 1/16 inch, should be left between the metal plates to increase penetration of the weld.
2. Position the metal so that the joint to be welded will be in the horizontal position.
3. The torch should be held 75 to 80 degrees to the surface of the weld and the back of the torch should be tipped downward so that the electrode is pointing up toward the weld at a 15 degree angle. The filler rod is held at a 20 degree angle to the plate.
4. Lower the helmet and strike the arc.

5. Move the filler rod into the leading edge of the molten puddle and let a drop or two of molten filler metal fill the puddle.
6. Withdraw the filler rod about 1/2 inch from the arc so the torch and puddle can be moved in the direction of travel; be sure to keep the end of the rod in the shielded area.
7. Advance the puddle while using the torch to maintain a uniform bead width. Then reinsert the filler rod into the center of the molten puddle at the point of the arc; let a drop or two of molten filler metal fill the puddle.
8. Repeat the procedure until the weld is complete.
9. Stop just as you reach the end of the plate and let off the foot control. Keep the torch in place for a few seconds after the end of the weld.
10. Examine the weld for penetration and bead appearance.
11. Turn in the weld to the instructor for grading.

LAP JOINT

1. Lower the helmet. Tack weld two pieces of mild steel together to form a lap joint. "Cover" should be said before striking an arc.
2. Position the metal so that the joint to be welded will be in the horizontal position.
3. The electrode should be held 45 degrees to the surface of the weld and pointed forward at 70 to 80 degrees from the weld axis. The filler rod is held at a 20 degree angle to the plate.
4. Lower the helmet and strike the arc.
5. Move the filler rod into the leading edge of the molten puddle and let a drop or two of molten filler metal fill the puddle.
6. Withdraw the filler rod about 1/2 inch from the arc so the torch and puddle can be moved in the direction of travel; be sure to keep the end of the rod in the shielded area.
7. Advance the puddle while using the torch to maintain a uniform bead width. Then reinsert the filler rod into the center of the molten puddle at the point of the arc; let a drop or two of molten filler metal fill the puddle.
8. Repeat the procedure until the weld is complete.
9. Stop just as you reach the end of the plate and let off the foot control. Keep the torch in place for a few seconds after the end of the weld.
10. Examine the weld for penetration and bead appearance.
11. Turn in the weld to the instructor for grading.

T-FILLET JOINT

1. Lower the helmet. Tack weld two pieces of mild steel together to form a T joint. "Cover" should be said before striking an arc.
2. Position the metal so that the joint to be welded will be in the horizontal position.
3. The electrode should be held 45 degrees to the surface of the weld and pointed forward at 70 to 80 degrees from the weld axis. The filler rod is held at a 15 to 20 degree angle to the plate.
4. Lower the helmet and strike the arc.
5. Move the filler rod into the leading edge of the molten puddle and let a drop or two of molten filler metal fill the puddle.
6. Withdraw the filler rod about 1/2 inch from the arc so the torch and puddle can be moved in the direction of travel; be sure to keep the end of the rod in the shielded area.

7. Advance the puddle while using the torch to maintain a uniform bead width. Then reinsert the filler rod into the center of the molten puddle at the point of the arc; let a drop or two of molten filler metal fill the puddle.
8. Repeat the procedure until the weld is complete.
9. Stop just as you reach the end of the plate and let off the foot control. Keep the torch in place for a few seconds after the end of the weld.
10. Examine the weld for penetration and bead appearance.
11. Turn in the weld to the instructor for grading.

Postwelding Procedure

Refer to JS 3.1 for postwelding procedures.

UNIT III - ARC WELDING

Job Sheet 3.4: Welds in the Vertical Position

Objective

At the completion of this job sheet, the student will be able to perform a butt, lap, and T-fillet weld in the vertical position using a GTAW welder.

Tools and Equipment Needed

1. GTAW machine and accessories
2. Protective clothing
3. Safety goggles*
4. Helmet
5. Adjustable wrench or appropriate open-end wrench
6. Shielding gas cylinder
7. Tungsten
8. Pliers

* CAUTION: Everyone participating in or observing the procedure should wear appropriate protective eyewear. Safety precautions must be observed while in the shop area.

Materials Needed

1. Filler metal - per instructor
2. Mild steel plates - size to be determined by the instructor

Prewelding Procedure

Refer to JS 3.1 for prewelding procedures.

Welding Procedure

BUTT JOINT

1. Lower the helmet. Tack weld two pieces of mild steel together to form a butt joint. “Cover” should be said before striking an arc. If the metal is thicker than 1/8 inch, the edges of the joint should be beveled to increase penetration. A space, approximately 1/16 inch, should be left between the metal plates to increase penetration of the weld.
2. Position the metal so that the joint to be welded will be in the vertical position. For thicker metal, it is best to weld with the weld pool moving from the bottom to the top, or vertically up. For thinner metal, it is best to weld with the pool moving from the top to the bottom, or vertically down.
3. The torch should be held perpendicular to the surface of the weld and tipped down so that the torch is 75 to 80 degrees from the base metal. The filler rod is held at an angle of approximately 35 to 45 degrees to the plate.

4. Lower the helmet and strike the arc.
5. Move the filler rod into the leading edge of the molten puddle and let a drop or two of molten filler metal fill the puddle.
6. Withdraw the filler rod about 1/2 inch from the arc so the torch and puddle can be moved in the direction of travel; be sure to keep the end of the rod in the shielded area.
7. Advance the puddle while using the torch to maintain a uniform bead width. Then reinsert the filler rod into the center of the molten puddle at the point of the arc; let a drop or two of molten filler metal fill the puddle.
8. Repeat the procedure until the weld is complete.
9. Stop just as you reach the end of the plate and let off the foot control. Keep the torch in place for a few seconds after the end of the weld.
10. Examine the weld for penetration and bead appearance.
11. Turn in weld to the instructor for grading.

LAP JOINT

1. Lower the helmet. Tack weld two pieces of mild steel together to form a lap joint. "Cover" should be said before striking an arc.
2. Position the metal so that the joint to be welded will be in the vertical position. For thicker metal, it is best to weld with the weld pool moving from the bottom to the top, or vertically up. For thinner metal, it is best to weld with the pool moving from the top to the bottom, or vertically down.
3. The torch should be centered over the root of the weld and tipped down so that the torch is 75 to 80 degrees from the base metal. The filler rod is held at an angle of approximately 35 to 45 degrees to the plate.
4. Lower the helmet and strike the arc.
5. Move the filler rod into the leading edge of the molten puddle and let a drop or two of molten filler metal fill the puddle.
6. Withdraw the filler rod about 1/2 inch from the arc so the torch and puddle can be moved in the direction of travel; be sure to keep the end of the rod in the shielded area.
7. Advance the puddle while using the torch to maintain a uniform bead width. Then reinsert the filler rod into the center of the molten puddle at the point of the arc; let a drop or two of molten filler metal fill the puddle.
8. Repeat the procedure until the weld is complete.
9. Stop just as you reach the end of the plate and let off the foot control. Keep the torch in place for a few seconds after the end of the weld.
10. Examine the weld for penetration and bead appearance.
11. Turn in weld to the instructor for grading.

T-FILLET JOINT

1. Lower the helmet. Tack weld two pieces of mild steel together to form a T joint. "Cover" should be said before striking an arc.
2. Position the metal so that the joint to be welded will be in the vertical position. For thicker metal, it is best to weld with the weld pool moving from the bottom to the top, or vertically up. For thinner metal, it is best to weld with the pool moving from the top to the bottom, or vertically down.
3. The torch should be centered over the root of the weld and tipped down so that the torch is 75 to 80 degrees from the base metal. The filler rod is held at an angle of approximately 35 to 45 degrees to the plate.

4. Lower the helmet and strike the arc.
5. Move the filler rod into the leading edge of the molten puddle and let a drop or two of molten filler metal fill the puddle.
6. Withdraw the filler rod about 1/2 inch from the arc so the torch and puddle can be moved in the direction of travel; be sure to keep the end of the rod in the shielded area.
7. Advance the puddle while using the torch to maintain a uniform bead width. Then reinsert the filler rod into the center of the molten puddle at the point of the arc; let a drop or two of molten filler metal fill the puddle.
8. Repeat the procedure until the weld is complete.
9. Stop just as you reach the end of the plate and let off the foot control. Keep the torch in place for a few seconds after the end of the weld.
10. Examine the weld for penetration and bead appearance.
11. Turn in weld to the instructor for grading.

Postwelding Procedure

Refer to JS 3.1 for postwelding procedures.

UNIT III - ARC WELDING

Job Sheet 3.5: Welds in the Overhead Position

Objective

At the completion of this job sheet, the student will be able to perform a butt, lap, and T-fillet weld in the overhead position using a GTAW welder.

Tools and Equipment Needed

1. GTAW machine and accessories
2. Protective clothing
3. Safety goggles*
4. Helmet
5. Adjustable wrench or appropriate open-end wrench
6. Shielding gas cylinder
7. Tungsten
8. Pliers

* CAUTION: Everyone participating in or observing the procedure should wear appropriate protective eyewear. Safety precautions must be observed while in the shop area.

Materials Needed

1. Filler metal - per instructor
2. Mild steel plates - size to be determined by the instructor

Prewelding Procedure

Refer to JS 3.1 for prewelding procedures.

Welding Procedure:

BUTT JOINT

1. Lower the helmet. Tack weld two pieces of mild steel together to form a butt joint. “Cover” should be said before striking an arc. If the metal is thicker than 1/8 inch, the edges of the joint should be beveled to increase penetration. A space, approximately 1/16 inch, should be left between the metal plates to increase penetration of the weld.
2. Position the metal so that the joint to be welded will be in the overhead position.
3. The electrode should be perpendicular to the surface of the weld and pointed forward with the torch approximately 70 to 80 degrees from the weld axis. The filler rod is held at a 15 to 20 degree angle to the plate.
4. Lower the helmet and strike the arc.

5. Move the filler rod into the leading edge of the molten puddle and let a drop or two of molten filler metal fill the puddle.
6. Withdraw the filler rod about 1/2 inch from the arc so the torch and puddle can be moved in the direction of travel; be sure to keep the end of the rod in the shielded area.
7. Advance the puddle while using the torch to maintain a uniform bead width. Then reinsert the filler rod into the center of the molten puddle at the point of the arc; let a drop or two of molten filler metal fill the puddle.
8. Repeat the procedure until the weld is complete.
9. Stop just as you reach the end of the plate and let off the foot control. Keep the torch in place for a few seconds after the end of the weld.
10. Examine the weld for penetration and bead appearance.
11. Turn in weld to the instructor for grading.

LAP JOINT

1. Lower the helmet. Tack weld two pieces of mild steel together to form a lap joint. "Cover" should be said before striking an arc. If the metal is thicker than 1/8 inch, the edges of the joint should be beveled to increase penetration.
2. Position the metal so that the joint to be welded will be in the overhead position.
3. The electrode should be held at a 45 degree angle to the surface of the weld and pointed forward at approximately 70 to 80 degrees from the weld axis. The filler rod is held at a 15 to 20 degree angle to the plate.
4. Lower the helmet and strike the arc.
5. Move the filler rod into the leading edge of the molten puddle and let a drop or two of molten filler metal fill the puddle.
6. Withdraw the filler rod about 1/2 inch from the arc so the torch and puddle can be moved in the direction of travel; be sure to keep the end of the rod in the shielded area.
7. Advance the puddle while using the torch to maintain a uniform bead width. Then reinsert the filler rod into the center of the molten puddle at the point of the arc; let a drop or two of molten filler metal fill the puddle.
8. Repeat the procedure until the weld is complete.
9. Stop just as you reach the end of the plate and let off the foot control. Keep the torch in place for a few seconds after the end of the weld.
10. Examine the weld for penetration and bead appearance.
11. Turn in the weld to the instructor for grading.

T-FILLET JOINT

1. Lower the helmet. Tack weld two pieces of mild steel together to form a T joint. "Cover" should be said before striking an arc.
2. Position the metal so that the joint to be welded will be in the overhead position.
3. The electrode should be held at a 45 degree angle to the surface of the weld and pointed forward at approximately 70 to 80 degrees from the weld axis. The filler rod is held at a 15 to 20 degree angle to the plate.
4. Lower the helmet and strike the arc.
5. Move the filler rod into the leading edge of the molten puddle and let a drop or two of molten filler metal fill the puddle.

6. Withdraw the filler rod about 1/2 inch from the arc so the torch and puddle can be moved in the direction of travel; be sure to keep the end of the rod in the shielded area.
7. Advance the puddle while using the torch to maintain a uniform bead width. Then reinsert the filler rod into the center of the molten puddle at the point of the arc; let a drop or two of molten filler metal fill the puddle.
8. Repeat the procedure until the weld is complete.
9. Stop just as you reach the end of the plate and let off the foot control. Keep the torch in place for a few seconds after the end of the weld.
10. Examine the weld for penetration and bead appearance.
11. Turn in weld to the instructor for grading.

Postwelding Procedure

Refer to JS 3.1 for postwelding procedures.