Course	Agricultural Science II
Unit	Agricultural Mechanics II
Subunit	Oxyacetylene Welding
Lesson	Brazing on Mild Steel
Estimated Time	Three 50-minute blocks

Student Outcome

Braze on mild steel using an oxyacetylene outfit.

Learning Objectives

1. List some safety considerations for using the oxyacetylene outfit to braze and braze weld.
2. Explain what brazing is and how is it different from fusion welding and soldering.
3. Identify the advantages and disadvantages of brazing.
4. Explain the functions of flux in brazing procedures.
5. List some factors to consider when choosing brazing flux and filler.
6. Identify flux and filler materials commonly used for brazing mild steel.
7. Demonstrate general techniques to use when brazing and braze welding.

Grade Level Expectations

Resources, Supplies & Equipment, and Supplemental Information

Resources

1. PowerPoint Slides
   - PPt 1 – Differences Between Brazing and Fusion Welding
2. Activity Sheets
   - AS 1 – Running a Bead With Brazing Rod (Instructor)
   - AS 1 – Running a Bead With Brazing Rod (Student)
   - AS 2 – Braze Welding an Outside Corner Joint in Mild Steel (Instructor)
   - AS 2 – Braze Welding an Outside Corner Joint in Mild Steel (Student)
3. *Agricultural Mechanics Unit for Agricultural Science II* (Student Reference). University of Missouri-Columbia: Instructional Materials Laboratory, 2002.
4. *Curriculum Enhancement for Agricultural Mechanics Unit for Agricultural Science II*, "Unit III – Oxyacetylene Welding." University of Missouri-Columbia: Instructional Materials Laboratory, 2004.

Supplies & Equipment

- ❑ See AS 1 and AS 2 for materials and equipment needed to complete the Activity Sheets.

Supplemental Information

1. Internet Sites
   - ❑ Brazing Alloy Datasheets. Aufhauser Corporation. Accessed October 15, 2007, from http://www.brazing.com/products/Braze_Copper/.

2. Print
   - ❑ Althouse, A., C. Turnquist, W. Bowditch, and K. Bowditch. *Modern Welding.* Tinley Park, IL: Goodheart-Willcox, 2000.
   - ❑ Jeffus, L. *Welding Principles and Applications.* 5th ed. Clifton Park, NY: Thomson-Delmar Learning, 2004.
   - ❑ Phipps, L., and G. Miller. *Introduction to Agricultural Mechanics.* Upper Saddle River, NJ: Prentice Hall Interstate, 2004.

Interest Approach

Show students some typical assemblies made by welding (weldments) and some made by brazing (brazements). Ask students to compare the characteristics of the welded pieces to those of the brazed pieces. Lead the students in a discussion about the features of the brazed assemblies. These assemblies should highlight some of the characteristics of brazing and how brazing differs from fusion welding. Students might notice the following characteristics: different types of metal can be joined together, very thin pieces can be joined together or a very thin piece can be joined to a thick piece without distortion, nonmetal parts can be joined by brazing, and parts are not fused together by the process.

Communicate the Learning Objectives

1. List some safety considerations for using the oxyacetylene outfit to braze and braze weld.
2. Explain what brazing is and how is it different from fusion welding and soldering.
3. Identify the advantages and disadvantages of brazing.
4. Explain the functions of flux in brazing procedures.
5. List some factors to consider when choosing brazing flux and filler.
6. Identify flux and filler materials commonly used for brazing mild steel.
7. Demonstrate general techniques to use when brazing and braze welding.

Instructor Directions	Content Outline
Objective 1	**List some safety considerations for using the oxyacetylene outfit to braze and braze weld.**
Introduce the topic of brazing by discussing some of the safety procedures that should be observed for brazing and braze welding. Supplement with any additional procedures as needed.	The same safety procedures used when welding or cutting with the oxyacetylene outfit should be used for brazing procedures. Some additional precautions are listed below. 1. Make sure the work area has excellent ventilation. Brazing can produce fumes that cause serious illness and even death. Some of these fumes have no odor and produce no symptoms until hours after exposure. 2. If needed, supplement ventilation with an appropriate respirator. 3. Avoid letting fluxes come into contact with skin. If fluxes do touch the skin, wash the area thoroughly with soap and water. 4. Because of the presence of fumes and toxic chemicals, do not eat or store food in the shop. 5. Wash the face and hands after working with fluxes and other toxic chemicals. 6. Wear the same type of clothing and protective clothing when brazing as when welding or cutting. Sleeves should be buttoned, gloves should be worn,

Instructor Directions	Content Outline
	and additional protective gear should be used as needed. 7. Wear goggles with filter lenses appropriate for the work being done. Lenses with shade numbers 3 and 4 are commonly used for torch brazing. Consult the manufacturer's recommendations. 8. Make sure only trained personnel handle acids used for cleaning. Persons handling acid should wear appropriate protective equipment, including rubber gloves and goggles approved for use around chemicals.
Objective 2 *Compare brazing to fusion welding and soldering. Refer to PPt 1.* ☐ PPt 1 – Differences Between Brazing and Fusion Welding	**Explain what brazing is and how is it different from fusion welding and soldering.** Brazing is a process of joining materials by adding filler metal that becomes liquid at a temperature above 840°F but below the temperature at which the base materials start to melt. The filler is distributed by capillary action, which means that it is drawn into the space between closely fitted pieces. If the materials are joined by running a braze pool to fill a groove or make a fillet instead of by capillary action, the process is called braze welding. With brazing and braze welding, the base materials do not melt so that they flow together to produce the joint. With fusion welding, the base materials are melted. Soldering is similar to brazing, except that it is done at temperatures below 840°F. The filler is distributed by capillary action.
Objective 3 *Discuss advantages and disadvantages of brazing. Examples of brazed and welded joints can be used to reinforce the information or clarify any points the students might have missed in previous discussions.*	**Identify the advantages and disadvantages of brazing.** Advantages of brazing 1. Brazing is done at lower temperatures than fusion welding. a. Very thin parts can be joined together or thin parts can be joined to thick parts with less risk of burning them. b. There is less chance of warping the materials. c. There is less chance of adding stress to the joints.

Instructor Directions	Content Outline
	2. Dissimilar metals, such as copper and steel, can be joined together. 3. Metals can be joined to nonmetals. 4. Parts can be easily disassembled and realigned without being damaged. Disadvantages of brazing 1. Brazed joints may not be as strong as similar joints made by fusion welding. 2. Assemblies that include brazed joints can only be used in applications where the operating temperature is below the service temperature of the filler material. Service temperature is the highest temperature at which the material can be used. 3. Filler metal used for braze welding may not be as resistant to chemical solutions as the base metals are.
Objective 4 *The purposes of fluxes are discussed at right, followed by some of the considerations for choosing a particular flux and filler metal. If different fluxes and fillers or fluxes and fillers in different forms are regularly used in the shop, these could be shown to the students to help familiarize them with the materials they will be using.*	**Explain the functions of flux in brazing procedures.** Flux removes oxides from the filler and base material and keeps new oxides from forming. It helps the filler flow, spread evenly, and adhere to the base material. This is known as "wetting." Without flux, the filler would bead up and roll off the base material without sticking. It facilitates capillary action.
Objective 5	**List some factors to consider when choosing brazing flux and filler.** Compatibility of the flux and filler with the base material – Use of fluxes and fillers that are not recommended for a particular application can result in joints that corrode, are brittle, and lack strength. Possible health risks – Certain fluxes produce toxic fumes or can be harmful to the skin. Brazing and service temperature required: The chemical composition of a filler affects the temperature at which it melts and at which it can be used.

Instructor Directions	Content Outline
	How the flux and filler are to be applied – Flux is available as a powder, liquid, or paste, and filler is available as preformed shapes, powder, and as bare rods or rods with flux already applied.
Objective 6 *Borax and brass, a common flux and filler used with steel, are discussed at right. If students will be using different or additional fluxes and fillers, supplement or adapt this question as needed.*	**Identify flux and filler materials commonly used for brazing mild steel.** Borax or boric acid (borax and water) is a typical base in fluxes used on steel. Brass is a typical filler for brazing ferrous metals, such as mild steel. 1. Brass is an alloy made chiefly of copper and zinc. 2. Brazing fillers are often identified by the letter "B," for brazing, followed by the symbols for the metals that make them up. For example, BCuZn indicates brass filler used for brazing. 3. Most brazing rods that are called "bronze" and used for brazing ferrous metals are, in fact, mostly made of brass, with only small amounts of tin. (Bronze is an alloy made chiefly of copper and tin.)
Objective 7 *General techniques for brazing and braze welding are discussed at right. Supplement with more detailed procedural information as needed. When students have completed the lesson on brazing, AS 1 and 2 should be used to demonstrate the correct way to run a braze-welded bead and to braze weld a corner joint using an oxyacetylene outfit. The student versions of these activities should be assigned to evaluate student competency.* AS 1 – Running a Bead With Brazing Rod	**Demonstrate general techniques to use when brazing and braze welding.** Check the fit and alignment of pieces before they are brazed or braze welded. 1. A close fit is essential for brazing. The clearance between pieces should be from .001 to .010 in. If the parts do not fit correctly, capillary action cannot occur. 2. Parts do not have to fit as closely for braze welding, but as with other welds, a good fit produces a stronger joint. Clean base materials prior to brazing or braze welding. 1. Parts to be joined by brazing must be clean for capillary action to take place. 2. Cleaning is also important prior to braze welding. 3. Parts can be cleaned by chemical or mechanical means. a. Mechanical cleaning

Instructor Directions	Content Outline
AS 2 – Braze Welding an Outside Corner Joint in Mild Steel	– Use of grinding, sanding, and wire brushing to remove surface dirt – Should be followed by washing and drying to remove particles knocked loose while cleaning b. Chemical cleaning – Use of chemicals to remove oil and grease that would be ground into the surface by mechanical cleaning – Use of acids or other solutions to remove rust and scale (pickling) – Should be followed by washing and drying Adjust the torch to the correct flame. 1. A carburizing flame produces a joint with a neat appearance, but strength may be sacrificed. 2. An oxidizing flame produces a joint that is strong but may be rough looking. 3. A neutral flame generally gives the best results for brazing and welding under normal conditions. Do not overheat the base material, filler, or flux when brazing with a torch. 1. Acetylene produces a flame with a very hot inner cone but relatively cool outer flame. If acetylene is used, care must be taken to avoid overheating a small area instead of heating a larger area uniformly. 2. Overheated flux can stop working as a flux and contaminate the joint. 3. If flux is overheated, it must be removed before continuing the process.
Application: AS 1 – Running a Bead With Brazing Rod AS 2 – Braze Welding an Outside Corner Joint in Mild Steel	AS 1 – AS 2 Results will vary. Other activities 1. Obtain empty metal containers (e.g., soup or soda cans) and punch holes in the bottom of them. Have students braze weld the holes to seal them. To check their work, have students put water in the cans to see if they hold water.

Instructor Directions	Content Outline
Closure/Summary	Brazing joins materials by adding filler metal through capillary action at a temperature above 840°F but below the melting temperature of the base material. It differs from fusion welding because the base material does not melt and flow together. Soldering is similar to brazing but is done at temperatures below 840°F. Flux is used during brazing to remove and prevent oxide formation, to help apply filler, and to promote capillary action. When selecting filler and flux, consider compatibility with base material, health risks such as toxic fumes, brazing and service temperature, and application method. Borax or boric acid is a typical base for fluxes used on steel. Brass is a typical filler for brazing ferrous metals, such as mild steel. Apply these general techniques for brazing: check the fit and alignment of pieces; clean base materials; adjust the torch to the correct flame; and do not overheat base material, filler, or flux. Safety considerations are similar to other oxyacetylene procedures, but give special attention to proper ventilation.
Evaluation: Quiz	Answers: 1. a 2. b 3. b 4. d 5. a 6. c 7. Students should list four of the following. a. Fumes from the fluxes, filler metals, and base metal coatings may be toxic. b. Fluxes can be harmful to skin and eyes. c. Fumes from fluxes, filler metals, and base metal coatings can contaminate food. d. Skin can be burned by hot surfaces and metal spatters. e. Skin and eyes can be burned by light rays. f. Skin and eyes can be irritated or burned by acids and cleaning solutions. 8. Students should list two of the following. a. A lower temperature can be used because the base metal does not have to melt. Using a lower temperature produces better results when joining very thin parts or joining thin parts to thick parts.

Instructor Directions	Content Outline
	There is also less chance of warping the materials and adding stress to the joints. b. Dissimilar metals can easily be joined because the base metal does not have to melt. c. The joined pieces can easily be disassembled without damaging them. 9. Students should list two of the following. a. Brazed joints may not be as strong as joints made by fusion welding. b. The lower service temperature of brazing filler metal limits its use to assemblies that will not be exposed to higher temperatures. c. Filler metal used for brazing may not be as resistant to chemical solutions as the base metal. 10. The incompatibility of flux and filler metal with the base metal can result in joints that corrode, are brittle, and lack strength.