OBJECTIVES

After completing this chapter, the student should be able to:

• Describe the manual, semiautomatic, machine, automatic, and automated joining processes.
• Explain the role that the welder plays in the operation of the manual, semiautomatic, machine, automatic, and automated joining processes.
• Give examples of the types of applications the manual, semiautomatic, machine, automatic, and automated joining processes are used for.

KEY TERMS

- automated joining
- automatic joining
- cycle time
- industrial robot
- machine joining
- manipulator
- manual joining
- pick-and-place robot
- semiautomatic joining
- sensors

INTRODUCTION

The first industrial robots were pick-and-place robots that were used to move material with little repetitive accuracy required. Today, computers have improved the accuracy, reliability, and functionality so that robots now serve as intelligent controllers for automation. The decreasing cost and advancements have made this technology possible, even for small businesses.

Automation has allowed manufacturers to increase productivity and cut costs, which makes their products more competitively priced.

This chapter gives you a general overview of automatic welding processes and robotics.
Manual Joining Processes

A manual joining process is one that is completely performed by hand. You control all of the manipulation, rate of travel, joint tracking, and, in some cases, the rate at which filler metal is added to the weld. The manipulation of the electrode or torch in a straight line or oscillating pattern affects the size and shape of the weld, Figure 25-1. The manipulation pattern may also be used to control the size of the weld pool during out-of-position welding. The rate of travel or speed at which the weld progresses along the joint affects the width, reinforcement, and penetration of the weld, Figure 25-2. The placement or location of the weld bead within the weld joint affects the strength, appearance, and possible acceptance of the joint. The rate at which filler metal is added to the weld affects the reinforcement, width, and appearance of the weld, Figure 25-3.

The most commonly used manual arc (MA) welding process is shielded metal arc welding (SMAW). The flexibility you have in performing the weld makes this process one of the most versatile. By changing the manipulation, rate of travel, or joint tracking, you can make an acceptable weld on a variety of material thicknesses, Figure 25-4.

Semiautomatic Joining Processes

A semiautomatic joining process is one in which the filler metal is fed into the weld automatically. You control most other functions. The addition of filler metal to the weld by an automatic wire-feeder system enables you to increase the uniformity of welds, productivity,
and weld quality. The distance of the welding gun or torch from the work remains constant. This gives you better manipulative control as compared to, for example, shielded metal arc welding, in which the electrode holder starts at a distance of 14 in. (356 mm) from the work. This distance exaggerates the slightest accidental movement made during the first part of the weld, Figure 25-5. In the SMAW process, the electrode holder must be lowered steadily as the weld progresses to feed the electrode and maintain the correct arc length, Figure 25-6. This constant changing of the distance above the work causes you to shift your body position frequently. This change, too, may affect the consistency of the weld.

Because the filler metal is being fed from a large spool, you do not have to stop welding to change filler electrodes or filler metal. SMA electrodes cannot be used completely as they have a waste stub of approximately 2 in. (51 mm). This waste stub represents approximately 15% of the filler metal that must be discarded. The frequent stopping for rod and electrode changes, followed by restarting, wastes time and increases the number of weld craters. These craters are often a source of cracks and other weld discontinuities, Figure 25-7. In some welding procedures each weld crater must be chipped and ground before the weld can be restarted. These procedures can take up to 10 minutes—time that can be used for welding in a semiautomatic welding process.

The most commonly used semiautomatic (SA) arc welding processes are gas metal arc welding (GMAW)
and flux cored arc welding (FCAW). Table 25-2 lists several other semiautomatic processes.

### Machine Joining Processes

A **machine joining** process is one in which the welding is performed by equipment and you control the welding progress by making adjustments as required. The parts being joined may or may not be loaded and unloaded automatically. You may monitor the joining progress by watching it directly, observing instruments only, or using a combination of both methods. Adjustments in travel speed, joint tracking, work-to-gun or work-to-torch distance, and current settings may be needed to ensure that the joint is made according to specifications.

The work may move past a stationary welding or joining station, Figure 25-8, or it may be held stationary and the welding machine moves on a beam or track along the joint, Figure 25-9. On some large machine welds, the operator may ride with the welding head along the path of the weld. During the assembly of the external fuel tanks used for the space shuttle, two operators were required for a few of the machine welds. One operator watched the root side of the weld while the other observed the face side of the weld. They were able to communicate with each other so that any needed changes could be made.

To minimize adjustments during machine welds, a test weld is often performed just before the actual weld is produced. This practice weld helps increase the already high reliability of machine welds.

### Automated Joining

**Automated joining** processes are similar to automatic joining except that they are flexible and more easily adjusted or changed. Unlike automatic joining, there is no dedicated machine for each product. The equipment can be easily adapted or changed to produce a wide variety of high-quality welds.

The industrial robot is rapidly becoming the main component in automated welding or joining stations. The welding or joining cycles are controlled by computers or microprocessors. The flexibility provided by automated workstations makes it possible for even small companies with limited production runs to invest in automated equipment. The equipment is controlled by programs, or a series of machine commands expressed in numerical codes, that direct the welding, cutting, assembling, or any other activities. The programs can be stored and quickly changed. Some systems can store and retrieve many different programs internally. Other systems are controlled by a host computer. Both types of systems can speed up production when frequent changes are required.

### Industrial Robots

An **industrial robot** is a “reprogrammable, multifunctional manipulator designed to move material, parts, tools, or specialized devices through variable programmed motions for the performance of a variety of tasks.” Industrial robots are primarily powered by electric stepping motors, hydraulics, or pneumatics and are controlled by a program, Figure 25-11.

Robots can be used to perform a variety of industrial functions, including grinding, painting, assembling,
machining, inspecting, flame cutting, product handling, and welding.

Robots range in size and complexity from small desktop units capable of lifting only a few ounces to large floor models capable of lifting tons. Most robots can perform movements in three basic directions: longitudinal (X), transverse (Y), and vertical (Z), Figure 25-12. The tool end of the robot arm may also be jointed so that it can tilt and rotate, Figure 25-13.

The robot may be used with other components to increase production and the flexibility of the system. A computer or microprocessor can synchronize the robot's operation to petitioners, conveyors, automatic fixtures, and other production machines. Parallel or
FIGURE 25-9  Automatic GTA machine welding along the seam of a stationary pipe.  The Lincoln Electric Company

FIGURE 25-10  Typical GTAW automatic welding program.  © Cengage Learning 2012

FIGURE 25-11  Robot control unit.  The Lincoln Electric Company

FIGURE 25-12  Machine axis.  Reproduced with permission from FANUC Robotics America Corporation © FANUC Robotics America Corporation.  All rights reserved.
multiple workstations increase the duty cycle (the fraction of time during which welding or work is being done) and reduce cycle time (the period of time from starting one operation to starting another), Figure 25-14. Parts can be loaded or unloaded by the operator at one station while the robot welds at another station.

**Safety**

The following precautions are recommended for the use of automatic welding equipment and robots:

- All personnel should be instructed in the safe operation of the robot.
- All personnel should be instructed in the location of an emergency power shutoff.
- The work area should be restricted to authorized persons only.
- The work area should have fences, gates, or other restrictions to prevent access by unauthorized personnel.

- **Sensors** should be mounted around the floor and work area to stop all movement when unauthorized personnel are detected in the work area during the operation.
- The arc welding light should be screened from other work areas.
- A breakaway toolholder should be used in case of accidental collision with the part, Figure 25-15.
- A signal should sound or flash before the robot starts moving.

**FIGURE 25-13** The tool end may be jointed so that it can tilt and rotate. Larry Jeffus

**FIGURE 25-14** Rotating worktable increases the work zone. Eutectic Corporation

**FIGURE 25-15** When using automatic equipment and robots, a break away collision sensor should be used. Applied Robotics, Inc.
SUMMARY

The automation of welding does not necessarily have to be in large shops. You may find that in some production applications it would be beneficial to use turntables or positioners. These can either fully or partially automate the welding process so that welder fatigue will be reduced. As you reduce welder fatigue with simple automation equipment, you can increase productivity significantly. It is important, therefore, not to look at automation as a major undertaking in every case. Many welding applications can be improved by using automated equipment, thereby reducing welder fatigue, increasing productivity, and reducing weld defects.

As the number of companies using automated and robotic equipment has increased, the cost of equipment has significantly decreased, and the versatility of the equipment has improved. Some equipment companies provide you with test runs of your product to help you determine the appropriateness of their equipment for your application. Such sample welds will help you determine which equipment is the most cost effective and appropriate for your application.

REVIEW QUESTIONS

1. Describe a manual joining process.
2. What is the most commonly used manual arc welding process?
3. What is a semiautomatic joining process?
4. Compare the distance of the welding gun or torch from the work in the semiautomatic joining process compared to the SMAW process.
5. What are the advantages of using filler metal that is fed from a large spool rather than filler electrodes?
6. What are the most commonly used semiautomatic arc welding processes?
7. Describe a machine joining process.
8. What type of adjustments to the equipment might be needed in a machine joining process?
9. Describe an automatic joining process.
10. Why is automatic welding or brazing best suited to large-volume production runs?
11. How are automated joining processes different from automatic joining?
12. What are automated joining processes controlled by?
13. What functions can industrial robots perform?
14. What three basic directions can most robots perform movements in?
15. What is a duty cycle?
16. Discuss several safety precautions that should be followed when using automatic welding equipment and robots.