
Machinists

(O*NET 51-4041.00)

Significant Points

- Machinists learn in apprenticeship programs, informally on the job, in vocational high schools, and in community or technical colleges.
- Many entrants previously have worked as machine setters, operators, or tenders.
- Although employment is projected to decline, job opportunities are expected to be good.

Nature of the Work

Machinists use machine tools, such as lathes, milling machines, and machining centers, to produce precision metal parts. Although they may produce large quantities of one part, precision machinists often produce small batches or one-of-a-kind items. They use their knowledge of the working properties of metals and their skill with machine tools to plan and carry out the operations needed to make machined products that meet precise specifications.

Machinists first review electronic or written blueprints or specifications for a job before they machine a part. Next, they calculate where to cut or bore into the workpiece—the piece of steel, aluminum, titanium, plastic, silicon or any other material that is being shaped. They determine how fast to feed the workpiece into the machine and how much material to remove. They then select tools and materials for the job, plan the sequence of cutting and finishing operations, and mark the workpiece to show where cuts should be made.

After this layout work is completed, machinists perform the necessary machining operations. They position the workpiece on the machine tool—drill press, lathe, milling machine, or other type of machine—set the controls, and make the cuts. During the machining process, they must constantly monitor the feed rate and speed of the machine. Machinists also ensure that the workpiece is properly lubricated and cooled because the machining of metal products generates a significant amount of heat. The temperature of the workpiece is a key concern because most metals expand when heated; machinists must adjust the size of their cuts relative to the temperature.

During the cutting process, machinists detect problems by listening for specific sounds—for example, that of a dull cutting tool or excessive vibration. Dull cutting tools are removed and replaced. Cutting speeds are adjusted to compensate for harmonic vibrations, which can decrease the accuracy of cuts, particularly on newer high-speed spindles and lathes. After the work is completed, machinists use both simple and highly sophisticated measuring tools to check the accuracy of their work against blueprints.

Some machinists, often called production machinists, may produce large quantities of one part, especially parts requiring the use of complex operations and great precision. Many modern machine tools are computer numerically controlled (CNC). CNC machines, following a computer program, control the cutting tool speed, change dull tools, and perform all of the necessary cuts to create a part. Frequently, machinists

work with computer control programmers to determine how the automated equipment will cut a part. (See the section on computer control programmers and operators elsewhere in the *Handbook*.) The machinist determines the cutting path, speed of the cut and the feed rate, and the programmer converts path, speed, and feed information into a set of instructions for the CNC machine tool.

Because most machinists train in CNC programming, they may write basic programs themselves and often modify programs in response to problems encountered during test runs. Modifications, called offsets, not only fix problems, but they also improve efficiency by reducing manufacturing time and tool wear. After the production process is designed, computer control operators implement it by performing relatively simple and repetitive operations.

Some manufacturing techniques employ automated parts loaders, automatic tool changers, and computer controls, allowing machines to operate without anyone present. One production machinist, working 8 hours a day, might monitor equipment, replace worn cutting tools, check the accuracy of parts being produced, adjust offsets, and perform other tasks on several CNC machines that operate 24 hours a day. In the off-hours, during what is known as “lights-out manufacturing,” a factory may need only a few machinists to monitor the entire factory.

Maintenance machinists repair or make new parts for existing machinery. After an industrial machinery mechanic or maintenance worker discovers the broken part of a machine, they give the broken part to the machinist. (See the section on industrial machinery mechanics and maintenance workers elsewhere in the *Handbook*.) To replace broken parts, maintenance machinists refer to blueprints and perform the same machining operations that were needed to create the original part. While production machinists are concentrated in a few industries, maintenance machinists work in many manufacturing industries.

Because the technology of machining is changing rapidly, machinists must learn to operate a wide range of machines. Some newer machines use lasers, water jets, or electrified wires to cut the workpiece. While some of the computer controls are similar to other machine tools, machinists must understand the unique cutting properties of these different machines. As engineers create new types of machine tools and



Machinists change worn cutting tools on computer-controlled machines.

Projections data from the National Employment Matrix

| Occupational Title | SOC Code | Employment, 2006 | Projected employment, 2016 | Change, 2006-16 | |
|--------------------|----------|------------------|----------------------------|-----------------|---------|
| | | | | Number | Percent |
| Machinists..... | 51-4041 | 397,000 | 384,000 | -12,000 | -3 |

NOTE: Data in this table are rounded. See the discussion of the employment projections table in the *Handbook* introductory chapter on *Occupational Information Included in the Handbook*.

new materials to machine, machinists must constantly learn new machining properties and techniques.

Work environment. Today, most machine shops are relatively clean, well lit, and ventilated. Many computer-controlled machines are partially or totally enclosed, minimizing the exposure of workers to noise, debris, and the lubricants used to cool workpieces during machining. Nevertheless, working around machine tools presents certain dangers, and workers must follow safety precautions. Machinists wear protective equipment, such as safety glasses to shield against bits of flying metal and earplugs to dampen machinery noise. They also must exercise caution when handling hazardous coolants and lubricants, although many common water-based lubricants present little hazard. The job requires stamina because machinists stand most of the day and, at times, may need to lift moderately heavy workpieces. Modern factories use autoloaders and overhead cranes to reduce heavy lifting.

Many machinists work a 40-hour week. Evening and weekend shifts are becoming more common as companies extend hours of operation to make better use of expensive machines. However, this trend is somewhat offset by lights-out manufacturing that uses fewer machinists and the use of machine operators for less desirable shifts. Overtime is common during peak production periods.

Training, Other Qualifications, and Advancement

Machinists train in apprenticeship programs, vocational schools, or community or technical colleges, or informally on the job. Many entrants previously have worked as machine setters, operators, or tenders.

Education and training. There are many different ways to become a skilled machinist. Many entrants previously have worked as machine setters, operators, or tenders. In high school, students should take math courses, especially trigonometry, and, if available, courses in blueprint reading, metalworking, and drafting. After high school, some machinists learn entirely on the job, but most acquire their skills in a mix of classroom and on-the-job training. Formal apprenticeship programs, typically sponsored by a union or manufacturer, are an excellent way to learn the job of machinist, but are often hard to get into. Apprentices usually must have a high school diploma, GED, or the equivalent, and most have taken algebra and trigonometry classes.

Apprenticeship programs consist of paid shop training and related classroom instruction lasting up to 4 years. In shop training, apprentices work almost full time and are supervised by an experienced machinist while learning to operate various machine tools. Classroom instruction includes math, physics, materials science, blueprint reading, mechanical drawing, and quality and safety practices. In addition, as machine shops have increased their use of computer-controlled equipment,

training in the operation and programming of CNC machine tools has become essential. Apprenticeship classes are often taught in cooperation with local community colleges or vocational-technical schools. A growing number of machinists are learning the trade through 2-year associate degree programs at community or technical colleges. Graduates of these programs still need significant on-the-job experience before they are fully qualified.

Certification and other qualifications. People interested in becoming machinists should be mechanically inclined, have good problem-solving abilities, be able to work independently, and be able to do highly accurate work (tolerances may reach 50/1,000,000ths of an inch) that requires concentration and physical effort. Experience working with machine tools is helpful. In fact, many entrants have worked as machine setters, operators, or tenders.

To boost the skill level of machinists and to create a more uniform standard of competency, a number of training facilities, State apprenticeship boards, and colleges are implementing curriculums that incorporate national skills standards developed by the National Institute of Metalworking Skills (NIMS). After completing such a curriculum and passing practical and written exams, trainees are granted a NIMS credential. Completing a recognized certification program provides a machinist with better career opportunities and helps employers better judge the abilities of new hires. Journey-worker certification can be obtained from State apprenticeship boards after completing an apprenticeship.

As new automation is introduced, machinists normally receive additional training to update their skills. This training usually is provided by a representative of the equipment manufacturer or a local technical school. Some employers offer tuition reimbursement for job-related courses.

Advancement. Machinists can advance in several ways. Experienced machinists may become CNC programmers, tool and die makers, or mold makers, or be promoted to supervisory or administrative positions in their firms. A few open their own machine shops.

Employment

Machinists held about 397,000 jobs in 2006. About 78 percent of machinists work in manufacturing industries, such as machine shops and machinery, motor vehicle and parts, aerospace products and parts, and other transportation equipment manufacturing. Maintenance machinists work in most industries that use production machinery.

Job Outlook

Although employment of machinists is projected to decline slowly, job prospects are expected to be good.

Employment change. Employment of machinists is projected to decline slowly by 3 percent over the 2006-16 decade because of rising productivity among these workers and strong foreign competition in the manufacture of goods. Machinists will become more efficient as a result of the expanded use of and improvements in technologies such as CNC machine tools, autoloading, and high-speed machining. This allows fewer machinists to accomplish the same amount of work. Technology is not expected to affect the employment of machinists as significantly as that of some other production workers, however, because machinists monitor and maintain many automated systems. Due to modern production techniques, employers prefer workers, such as machinists, who have a wide range of skills and are capable of performing almost any task in a machine shop.

Job prospects. Despite the projected decline in employment, job opportunities for machinists should continue to be good as employers value the wide-ranging skills of these workers. Also, many young people with the necessary educational and personal qualifications needed to become machinists prefer to attend college or may not wish to enter production occupations. Therefore, the number of workers learning to be machinists is expected to be less than the number of job openings arising each year from the need to replace experienced machinists who retire or transfer to other occupations.

Employment levels in this occupation are influenced by economic cycles—as the demand for machined goods falls, machinists involved in production may be laid off or forced to work fewer hours. Employment of machinists involved in plant maintenance, however, often is more stable because proper maintenance and repair of costly equipment remains critical to manufacturing operations, even when production levels fall.

Earnings

Median hourly wage-and-salary earnings of machinists were \$16.71 in May 2006. The middle 50 percent earned between \$13.14 and \$20.82. The lowest 10 percent earned less than \$10.29, while the top 10 percent earned more than \$25.31. Median hourly wage-and-salary earnings in the manufacturing industries employing the largest number of machinists were:

| | |
|---|---------|
| Aerospace product and parts manufacturing | \$18.46 |
| Motor vehicle parts manufacturing | 18.27 |
| Metalworking machinery manufacturing | 17.36 |
| Machine shops; turned product; and screw, nut, and bolt manufacturing | 16.24 |
| Employment services | 11.98 |

Apprentices earn much less than experienced machinists, but earnings increase quickly as they improve their skills. Also most employers pay for apprentices' training classes.

Related Occupations

Occupations most closely related to that of machinist are other machining occupations, which include tool and die makers; machine setters, operators, and tenders—metal and plastic; and computer control programmers and operators. Maintenance machinists work closely with industrial machinery mechanics and maintenance workers.

Sources of Additional Information

For general information about a career in machining, contact:

► PrecisionMachineProductsAssociation, 6700 West Snowville Rd., Brecksville, OH 44141. Internet: <http://www.pmpa.org>

For a list of training centers and apprenticeship programs, contact:

► National Tooling and Machining Association, 9300 Livingston Rd., Fort Washington, MD 20744.

For more information on credential standards and apprenticeship, contact:

► The National Institute for Metalworking Skills, 10565 Fairfax Blvd., Suite 203, Fairfax, VA 22030.

Internet: <http://www.nims-skills.org/home/index.htm>

Information on the registered apprenticeship system with links to State apprenticeship programs may also be found on the U.S. Department of Labor's Web site: http://www.doleta.gov/atels_bat Apprenticeship information is also available from the U.S. Department of Labor's toll free helpline: (877) 872-5627.