young people with the necessary educational and personal qualifications needed to obtain machining skills may prefer to attend college or may not wish to enter production-related occupations. Therefore, the number of workers obtaining the skills and knowledge necessary to fill machinist jobs is expected to be less than the number of job openings arising each year from employment growth and from the need to replace experienced machinists who transfer to other occupations or retire.

Employment of machinists is expected to grow more slowly than the average for all occupations over the 2000-10 period because of rising productivity among machinists. Productivity gains are resulting from the expanded use of computer-controlled machine tools and new technologies, such as high-speed machining, which reduce the time required for machining operations. This allows fewer machinists to accomplish the same amount of work previously performed by more workers. Technology is not expected to affect the employment of machinists as significantly as that of most other production occupations, however, because many of the unique operations performed by machinists cannot be efficiently automated. 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. In addition, firms are likely to retain their most skilled workers to operate and maintain expensive new machinery.

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 remain vital concerns, even when production levels fall.

Earnings

Median hourly earnings of machinists were $14.78 in 2000. The middle 50 percent earned between $11.43 and $18.39. The lowest 10 percent earned less than $9.01, while the top 10 percent earned more than $21.84. Median hourly earnings in the manufacturing industries employing the largest number of machinists in 2000 were:

Aircraft and parts	$16.86
Metalworking machinery	15.89
Industrial machinery, not elsewhere classified	14.66
Motor vehicles and equipment	14.24
Personnel supply services	8.80

Related Occupations

Occupations most closely related to that of machinist are other machining occupations. These include tool and die makers; machine setters, operators, and tenders—metal and plastic; and computer-control programmers and operators. Another occupation that requires precision and skill in working with metal is welding, soldering, and brazing workers.

Sources of Additional Information

For general information about machinists, contact:

➤ Precision Machine Products Association, 6700 West Snowville Rd., Brecksville, OH 44141-3292. Internet: **http://www.pmpa.org**

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

➤ National Tooling and Metalworking Association, 9300 Livingston Rd., Fort Washington, MD 20744. Internet: **http://www.ntma.org**

For general occupational information and a list of training programs, contact:

➤ PMA Educational Foundation, 6363 Oak Tree Blvd., Independence, OH 44131-2500. Internet: **http://www.pmaef.org**

Machine Setters, Operators, and Tenders—Metal and Plastic

(O*NET 51-4021.00, 51-4022.00, 51-4023.00, 51-4031.01, 51-4031.02, 51-4031.03, 51-4031.04, 51-4032.00, 51-4033.01, 51-4033.02, 51-4034.00, 51-4035.00, 51-4051.00, 51-4052.00, 51-4061.00, 51-4062.00, 51-4071.00, 51-4072.01, 51-4072.02, 51-4072.03, 51-4072.04, 51-4072.05, 51-4081.01, 51-4081.02, 51-4191.01, 51-4191.02, 51-4191.03, 51-4192.00, 51-4193.01, 51-4193.02, 51-4193.03, 51-4193.04, 51-4194.00, 51-4199.99)

Significant Points

- A few weeks of on-the-job training is sufficient for most workers to learn basic machine operations, but several years are required to become a skilled operator.
- Employment of most operators is expected to decline, while employment of multiple machine tool operators is projected to grow.

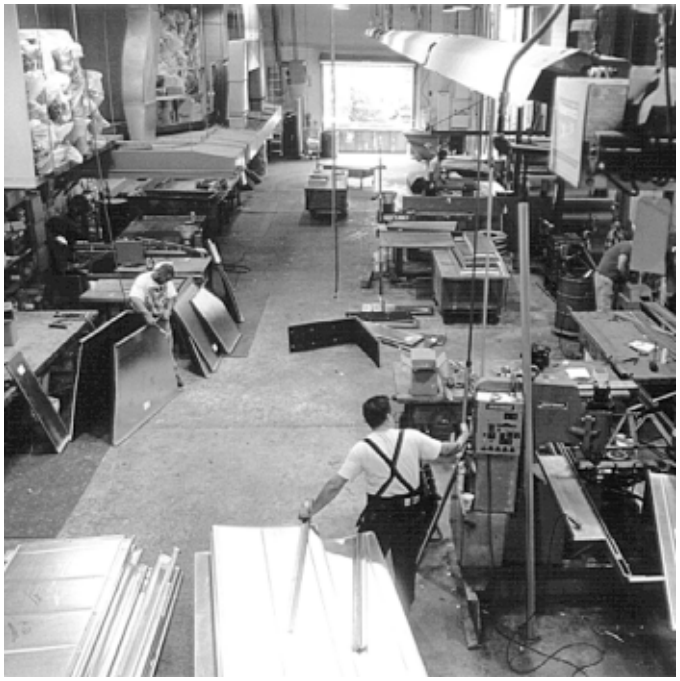
Nature of the Work

Consider the parts of a toaster, such as the metal or plastic housing or the lever that lowers the toast. These parts, and many other metal and plastic products, are produced by metalworking and plastics-working machine operators. In fact, machine tool operators in the metalworking and plastics industries play a major part in producing most of the consumer products on which we rely daily.

In general, these workers can be separated into two groups—those who set up machines for operation and those who tend the machines during production. Setup workers prepare the machines prior to production and may adjust the machinery during operation. Operators and tenders, on the other hand, primarily monitor the machinery during operation, sometimes loading or unloading the machine or making minor adjustments to the controls. Many workers both set up and operate equipment. Because the setup process requires an understanding of the entire production process, setters usually have more training and are more highly skilled than those who simply operate or tend machinery. As new automation simplifies the setup process, however, less skilled workers also are increasingly able to set up machines for operation.

Setters, operators, tenders, and setup operators usually are identified by the type of machine with which they work. Some examples of specific titles are drilling and boring machine toolsetters, milling and planing machine tenders, and lathe and turning-machine tool operators. Job duties usually vary based on the size of the firm and on the type of machine being operated. Although some workers specialize in one or two types of machinery, many are trained to set up or operate a variety of machines. Newer production techniques require machine operators to rotate between, and be proficient with, different machines. The rotating of assignments allows workers more varied work, but also requires them to have a wider range of skills.

Metalworking-machine setters and operators set up and tend machines that cut and form all types of metal parts. Traditionally, setup workers plan and set up the sequence of operations according to blueprints, layouts, or other instructions. They adjust speed, feed, and other controls; choose the proper coolants and lubricants; and select the instruments or tools for each operation. Using micrometers, gauges, and other precision measuring instruments, they also may compare the completed work with the tolerance limits stated in the specifications.



Machine setters, operators, and tenders, metal and plastic, operate machines that bend, cut, and shape metal and plastic material.

Although there are many different types of metalworking machine tools that require specific knowledge and skills, most operators perform similar tasks. Whether tending grinding machines that remove excess material from the surface of machined products or presses that extrude metal through a die to form wire, operators usually perform simple, repetitive operations that can be learned quickly. Typically, these workers place metal stock in a machine on which the operating specifications have already been set. They may watch one or more machines and make minor adjustments according to their instructions. Regardless of the type of machine they operate, machine tenders usually depend on skilled setup workers for major adjustments when the machines are not functioning properly.

Plastics-working machine operators set up and tend machines that transform plastic compounds—chemical-based products that can be produced in powder, pellet, or syrup form—into a wide variety of consumer goods such as toys, tubing, and auto parts. These products are manufactured using various methods, of which injection molding is the most common. The injection-molding machine heats and liquefies a plastic compound and forces it into a mold. After the part has cooled and hardened, the mold opens and the part is released. Many common kitchen products are produced using this method. To produce long parts such as pipes or window frames, an extruding machine usually is employed. These machines force a plastic compound through a die that contains an opening of the desired shape of the final product. Blow molding is another common plastics-working technique. Blow-molding machines force hot air into a mold that contains a plastic tube. As the air moves into the mold, the plastic tube is inflated to the shape of the mold, and a plastic container is formed. The familiar 2-liter soft drink bottles are produced using this method.

Workers in three different specialized occupations operate injection-molding machines: tenders, operators, and setters. Most other types of plastic machines function in a similar manner. Tenders remove the cooled plastic from the mold, loading the product into boxes. Operators monitor the many gauges on injection-molding machines, adjusting different inputs, pressures, and speeds to maintain quality. A typical injection-molding machine may have 25 different controls that can be adjusted. Setters or technicians set up the machines prior to operations. They are responsible for repairing any major problem.

Working Conditions

Most machine setters, operators, and tenders—metal and plastic work in areas that are clean, well lit, and well ventilated. Nevertheless, many operators require stamina because they are on their feet much of the day and may do moderately heavy lifting. Also, these workers operate powerful, high-speed machines that can be dangerous if strict safety rules are not observed. Most operators wear protective equipment, such as safety glasses and earplugs, to protect against flying particles of metal or plastic and against noise from the machines. However, many modern machines are totally enclosed, minimizing the exposure of workers to noise, dust, and lubricants used during machining. Other required safety equipment varies by work setting and machine. For example, workers in the plastics industry who work near materials that emit dangerous fumes or dust must wear face masks or self-contained breathing apparatus.

Most metalworking and plastics-working machine operators work a 40-hour week, but overtime is common during periods of increased production. Because many metalworking and plastics-working shops operate more than one shift daily, some operators work nights and weekends.

Employment

Machine setters, operators, and tenders—metal and plastic held about 1.6 million jobs in 2000. About 3 out of every 4 metalworking and plastics-working machine operators are found in 5 manufacturing industries—fabricated metal products, industrial machinery and equipment, rubber and miscellaneous plastics products, transportation equipment, and primary metals. The following tabulation shows the distribution of employment of metalworking and plastics-working machine operators by detailed occupation.

Cutting, punching, and press machine setters, operators, and tenders, metal and plastic	372,000
Molders and molding machine setters, operators, and tenders, metal and plastic	235,000
All other metal workers and plastic workers	150,000
Grinding, lapping, polishing, and buffing machine tool setters, operators, and tenders, metal and plastic	145,000
Extruding and drawing machine setters, operators, and tenders, metal and plastic	126,000
Multiple machine tool setters, operators, and tenders, metal and plastic	105,000
Lathe and turning machine tool setters, operators, and tenders, metal and plastic	84,000
Drilling and boring machine tool setters, operators, and tenders, metal and plastic	71,000
Plating and coating machine setters, operators, and tenders, metal and plastic	65,000
Forging machine setters, operators, and tenders, metal and plastic	54,000
Rolling machine setters, operators, and tenders, metal and plastic	49,000
Heat treating equipment setters, operators, and tenders, metal and plastic	43,000
Metal-refining furnace operators and tenders	40,000
Milling and planing machine setters, operators, and tenders, metal and plastic	34,000
Tool grinders, filers, and sharpeners	29,000
Model makers and patternmakers, metal and plastic	19,000
Lay-out workers, metal and plastic	18,000

Training, Other Qualifications, and Advancement

Machine setters, operators, and tenders—metal and plastic learn their skills on the job. Trainees begin by observing and assisting experienced workers, sometimes in formal training programs. Under supervision, they may start as tenders, supplying materials, starting and stopping the machine, or removing finished products from it. They then advance to the more difficult tasks performed by operators, such as adjusting feed speeds, changing cutting tools, or inspecting a finished product for defects. Eventually they become responsible for their own machines.

The complexity of the equipment largely determines the time required to become an operator. Most operators learn the basic machine operations and functions in a few weeks, but they may need several years to become skilled operators or to advance to the more highly skilled job of setter.

Setters or technicians normally need a thorough knowledge of the machinery and of the products being manufactured because they often plan the sequence of work, make the first production run, and determine which adjustments need to be made. Strong analytical abilities are particularly important to perform this job. Some companies have formal training programs for operators and setters, which combine classroom instruction with on-the-job training.

Although no special education is required for most operating jobs, employers prefer to hire applicants with good basic skills. Many require employees to have a high school education and to read, write, and speak English. Because machinery is becoming more complex and shop-floor organization is changing, employers increasingly look for persons with good communication and interpersonal skills. Mechanical aptitude, manual dexterity, and experience working with machinery also are helpful. Those interested in becoming machine setters, operators, and tenders can improve their employment opportunities by completing high school courses in shop and blueprint reading and by gaining a working knowledge of the properties of metals and plastics. A solid math background including courses in algebra, geometry, trigonometry, and basic statistics also is useful.

Job opportunities and advancement also can be enhanced by becoming certified in a particular machining skill. The National Institute for Metalworking Skills has developed standards for metalworking-machine operators. After taking a course approved by the organization and passing a written exam and performance requirement, the worker is issued a credential that formally recognizes him or her as competent in a specific machining operation. The Society of Plastics Industry, Inc., the national trade association representing plastics manufacturers, also certifies workers in the plastics industry. To achieve machine-operator certification, 2 years of experience operating a plastics-processing machine is recommended, and one must pass a computer-based exam.

Advancement for operators usually takes the form of higher pay, although there are some limited opportunities for operators to advance to new positions as well. For example, they can become multiple machine operators, setup operators, or trainees for the more highly skilled positions of machinist, tool and die maker, or computer control programmers or operators. Some setup workers may advance to supervisory positions. (See the statements on machinists, computer control programmers and operators, and tool and die makers elsewhere in the *Handbook*.)

Job Outlook

Employment trends for among the various machine setters, operators, and tenders—metal and plastic are expected to diverge over the 2000-10 period. In general, employment of these workers will be affected by the rate of technological implementation, the demand for the goods they produce, the effects of trade, and the reorganization of production processes. These trends are expected to spur employment growth among multiple machine tool operators; plastics-molding, core-making, and casting machine operators; and a number of miscellaneous operating positions. On the other hand, a decline in employment is projected for many machine tool operators, including cutting, punching, and press machine setters, operators, and tenders; and lathe and turning-machine tool workers. Despite differing rates of employment change, a large number of machine setter, operator, and tender jobs will become available due to an expected surge in retirements as the first of the baby boomers become eligible for retirement by the end of this decade.

One of the most important factors influencing employment change in this occupation is the implementation of laborsaving machinery. In order to remain competitive by improving quality and lowering production costs, many firms are adopting new technologies, such as computer-controlled machine tools and robots. Computer-controlled equipment allows operators to simultaneously tend a greater number of machines and often makes setup easier, thereby reducing the amount of time setup workers spend on each machine. Robots are being used to load and unload parts from machines. The lower-skilled manual machine tool operators and tenders are more likely to be eliminated by these new technologies because the functions they perform are more easily automated.

The demand for metalworking and plastics-working machine operators largely mirrors the demand for the parts they produce. Recent growth in the domestic economy, for example, has led to increased employment in a number of machine-operating occupations. In addition, the consumption of plastic products has grown as they have been substituted for metal goods in many consumer and manufactured products in recent years. This process is likely to continue and should result in stronger demand for machine operators in plastics than in metalworking.

Both the plastics and metal industries, however, face stiff foreign competition that is limiting the demand for domestically produced parts. One way in which larger U.S. producers have responded to this competition is by moving production operations to other countries where labor costs are lower. These moves are likely to continue, and will further reduce employment opportunities for many machine operators, setters, and tenders—metal and plastic in the United States.

Workers with a thorough background in machine operations, exposure to a variety of machines, and a good working knowledge of the properties of metals and plastics will be best able to adjust to this changing environment. In addition, new shop-floor arrangements will reward workers with good basic mathematics and reading skills, good communication skills, and the ability and willingness to learn new tasks. As workers are called upon to adapt to new production methods and to operate more machines, the number of multiple machine tool operators, setters, and tenders—metal and plastic will continue to rise.

Earnings

Earnings for machine operators can vary by size of the company, union/nonunion status, industry, and skill level and experience of the operator. Also, temporary employees, who are being hired in greater numbers, usually get paid less than company-employed workers. The median hourly earnings in 2000 for a variety of machine setters, operators, and tenders—metal and plastic were:

Model makers and patternmakers, metal and plastic	$16.07
Lay-out workers, metal and plastic	14.27
Lathe and turning machine tool setters, operators, and tenders, metal and plastic	13.77
Metal-refining furnace operators and tenders	13.47
Milling and planing machine setters, operators, and tenders, metal and plastic	13.25
Tool grinders, filers, and sharpeners	13.22
Multiple machine tool setters, operators, and tenders, metal and plastic	12.96
Rolling machine setters, operators, and tenders, metal and plastic	12.85
Heat treating equipment setters, operators, and tenders, metal and plastic	12.64
Drilling and boring machine tool setters, operators, and tenders, metal and plastic	12.25
Forging machine setters, operators, and tenders, metal and plastic	12.11
Grinding, lapping, polishing, and buffing machine tool setters, operators, and tenders, metal and plastic	11.71
Extruding and drawing machine setters, operators, and tenders, metal and plastic	11.66
Plating and coating machine setters, operators, and tenders, metal and plastic	11.23
Cutting, punching, and press machine setters, operators, and tenders, metal and plastic	11.03
Molders and molding machine setters, operators, and tenders, metal and plastic	10.40
All other metal workers and plastic workers	13.26

Approximately one-third of these workers are union members, about double the rate for other workers in the economy. Metalworking industries have a higher rate of unionization than does the plastics industry.

Related Occupations

Workers in occupations closely related to machine setters, operators, and tenders—metal and plastic include machinists, tool and die makers, assemblers and fabricators, computer control programmers and operators, and woodworkers.

Sources of Additional Information

For general information about machine setters, operators, and tenders—metal and plastic, contact:

➤ National Tooling and Metalworking Association, 9300 Livingston Rd., Fort Washington, MD 20744. Internet: **http://www.ntma.org**

➤ Precision Machining Association Educational Foundation, 6363 Oak Tree Blvd., Independence, OH 44131. Internet: **http://www.pmaef.org**

➤ Precision Machine Products Association, 6700 West Snowville Rd., Brecksville, OH 44141-3292. Internet: **http://www.pmpa.org**

➤ Society of Plastics Industry, 1801 K St. NW., Suite 600K, Washington, DC 20006-1301. Internet: **http://www.socplas.org** and **http://www.certifyme.org**

Tool and Die Makers

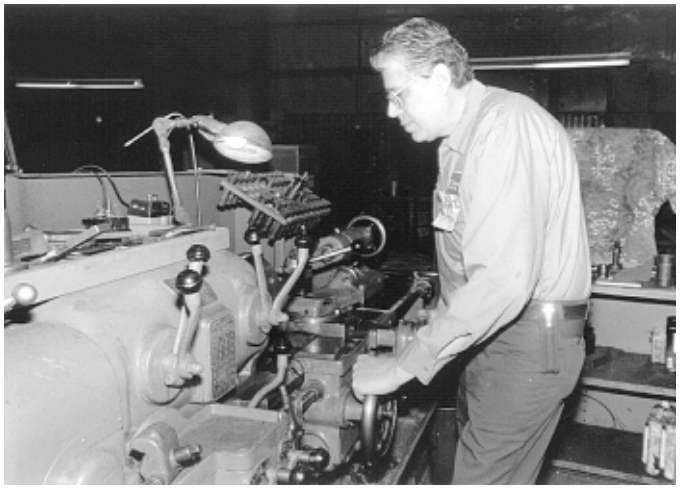
(O*NET 51-4111.00)

Significant Points

- Most tool and die makers train for 4 or 5 years in apprenticeships or postsecondary programs; employers typically recommend apprenticeship training.
- Jobseekers with the appropriate skills and background should enjoy excellent opportunities.

Nature of the Work

Tool and die makers are among the most highly skilled production workers in the economy. These workers produce tools, dies, and special guiding and holding devices that enable machines to manufacture a variety of products we use daily—from clothing and furniture to heavy equipment and parts for aircraft.



Tool and die makers use many types of machine tools.

Toolmakers craft precision tools that are used to cut, shape, and form metal and other materials. They also produce jigs and fixtures (devices that hold metal while it is bored, stamped, or drilled) and gauges and other measuring devices. Die makers construct metal forms (dies) that are used to shape metal in stamping and forging operations. They also make metal molds for diecasting and for molding plastics, ceramics, and composite materials. In addition to developing, designing and producing new tools and dies, these workers also may repair worn or damaged tools, dies, gauges, jigs, and fixtures.

To perform these functions, tool and die makers employ many types of machine tools and precision measuring instruments. They also must be familiar with the machining properties, such as hardness and heat tolerance, of a wide variety of common metals and alloys. As a result, tool and die makers are knowledgeable in machining operations, mathematics, and blueprint reading. In fact, tool and die makers often are considered highly specialized machinists. (See the statement on machinists elsewhere in the *Handbook*.)

Working from blueprints, tool and die makers first must plan the sequence of operations necessary to manufacture the tool or die. Next, they measure and mark the pieces of metal that will be cut to form parts of the final product. At this point, tool and die makers cut, drill, or bore the part as required, checking to ensure that the final product meets specifications. Finally, these workers assemble the parts and perform finishing jobs such as filing, grinding, and polishing surfaces.

Modern technology is changing the ways in which tool and die makers perform their jobs. Today, for example, these workers often use computer-aided design (CAD) to develop products and parts. Specifications entered into computer programs can be used to electronically develop drawings for the required tools and dies. Numerical tool and process control programmers use computer-aided manufacturing (CAM) programs to convert electronic drawings into computer programs that contain a sequence of cutting tool operations. (See the statement on computer-control programmers and operators elsewhere in the *Handbook*.) Once these programs are developed, computer numerically controlled (CNC) machines follow the set of instructions contained in the program to produce the part. (Computer-controlled machine tool operators or machinists normally operate CNC machines; however, tool and die makers are trained in both operating CNC machines and writing CNC programs, and they may perform either task. CNC programs are stored electronically