

Build machines, earn a living:

Opportunities in

# machinery manufacturing

by Michael Wolf

**M**achinery encompasses a vast range of products, from a huge industrial turbine that costs millions of dollars to a common lawnmower that sells for under \$100. Regardless of its size or cost, however, all machinery has one universally defining feature: it either reduces or eliminates the amount of human effort required to accomplish a task.

Machinery is critical to the production of many of the Nation's goods and services. Nearly every workplace in every industry uses some form of machinery. Some machines are specialized for a particular industry, such as farm tractors, while others have a more general use, such as air-conditioners.

Making these machines requires workers of many types. Engineers design machines and develop efficient ways to produce them. Machinists, welders, and other production workers program equipment to make machine parts. Managers, sales workers, and many other workers run the business of making machines and keep that business profitable.

Workers in the machinery manufacturing industry are well compensated for their skills; many workers in the machinery manufacturing industry are among the more highly paid in the economy.



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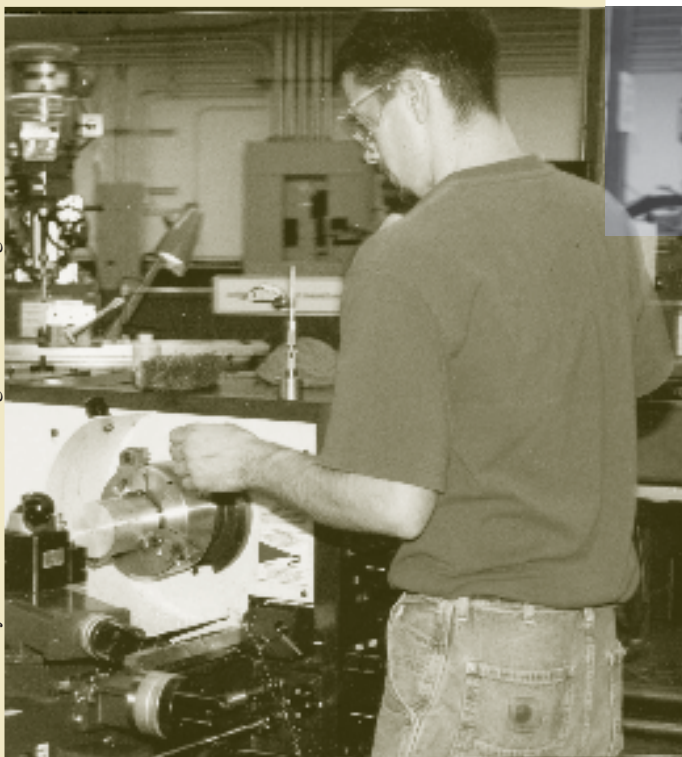


Photo courtesy of the National Tooling and Machining Association

Keep reading to learn more about this industry and the workers in it. The first section of the article identifies the variety of occupations that are needed to manufacture machinery. The second section describes the types of machinery that the industry produces and the industry's size and evolution. Subsequent sections describe the benefits and drawbacks of working in the industry, how to train for and advance in its occupations, and where to find more information.

## Who makes machines?

According to the U.S. Bureau of Labor Statistics (BLS), the machinery manufacturing industry provided 1.1 million jobs in 2004 in a wide variety of occupations. Creating and producing a machine requires engineers and technicians, production and assembly workers, supervisors and managers, and support personnel. (See table.)

### Design and testing

Before any work begins on assembling a piece of machinery, an extensive process of creating and testing its design takes place. This process usually takes several years, depending on the complexity of the machinery. The work is done primarily by engineers, technicians, and drafters.

Engineers do much of the design work. They start with an idea about what a new machine could do or how an existing one could be improved. Engineers might be trying to design a bulldozer that has more horsepower, for example, or one that moves dirt with more precision. To develop their ideas, engineers use computer modeling and simulation software to design a machine and test it for performance, cost, reliability, ease of use, and other factors.

Most engineers specialize in a particular facet of design. Mechanical engineers design a machine's moving parts, such as gears, levers, and pistons in engines and hydraulic systems. These workers also direct the work of mechanical engineering technicians who run tests on materials and parts prior to final assembly. For machines that have complicated electric or electronic systems, electrical and electronics engineers assist in the design and testing

process. Industrial engineers determine how to allocate a factory's resources—both workers and equipment—for optimal production. Engineering managers oversee the entire design process.

After a design is finalized and testing is completed, mechanical drafters create the plans that show production workers how to assemble the machine. Drafters provide specifications and diagrams for each part of the machine, as well as assembly instructions for the final product.

### Production

Production workers account for more than half of all jobs in the machinery manufacturing industry. Some of these workers create machinery components; others put the components together and complete the product. Supervisors and managers oversee the process.

**Parts production.** Metal and plastic workers create all of the parts that are needed

in the production and assembly of a machine. As production becomes

more automated, the jobs of most metal and plastic workers are becoming more complex.

Fewer workers simply operate machines; now, most workers also program machines using computer software and perform minor repairs on factory equipment.

Among the most skilled of metal and plastic workers are tool and die makers—and the machinery manufacturing industry employs about 30 percent of

these workers. Tool and die makers create precision tools and machines, often using computer-aided design software. Tool and die makers program factory equipment with specific instructions on where and how to cut, shape, and form metal and other materials to exact specifications. Operating computer-controlled machine tools, tool



Photo courtesy of the National Tooling and Machining Association

## Employment and earnings for the most common occupations in machinery manufacturing, May 2004

Occupation	Employment	Median annual earnings within the machinery manufacturing industry	Median annual earnings averaged across all industries
Team assemblers	113,520	\$26,470	\$23,750
Machine tool cutting setters, operators, and tenders, metal and plastic	73,580	30,010	27,350
Machinists	68,150	34,730	33,960
Welders, cutters, solderers, and brazers	53,630	30,270	30,620
First-line supervisors/managers of production and operating workers	40,770	48,210	44,740
Computer-controlled machine tool operators, metal and plastic	30,010	33,190	30,690
Mechanical engineers	29,890	59,640	66,320
Tool and die makers	28,280	41,220	42,740
Inspectors, testers, sorters, samplers, and weighers	23,110	32,410	28,410
General and operations managers	18,920	94,400	77,420
Engine and other machine assemblers	18,780	31,820	34,800
Sales representatives, wholesale and manufacturing, except technical and scientific products	18,400	51,520	45,400
Shipping, receiving, and traffic clerks	17,680	27,870	24,400
Maintenance and repair workers, general	16,760	35,940	30,710
Helpers, production workers	16,140	21,960	20,180
Structural metal fabricators and fitters	16,050	30,200	29,840
Mechanical drafters	14,760	41,230	43,000
Bookkeeping, accounting, and auditing clerks	14,060	29,900	28,570
Laborers and freight, stock, and material movers, hand	13,920	24,930	20,120
Industrial engineers	13,750	60,320	65,020

and die makers produce devices, such as jigs and fixtures, to hold metal while it is being worked on. They also produce gauges, other measuring devices, and dies to shape the metal.

Metal and plastic machine tool cutting setters, operators, and tenders use tools, dies, and jigs when they set up and operate machines to make parts out of raw materials. Because most of their machines now operate automatically, machine tool operators primarily monitor the machines and perform minor repairs as needed.

Computer control programmers and operators manage the automatic metalworking machines that mass produce individual parts. They also write computer pro-

grams, based on the specifications of each part, to tell the metalworking machines what to do.

Welding, soldering, and brazing workers operate machines that join two or more pieces of metal together. These workers also might weld with a hand torch.

Machinists make precision parts that require special skill to create or parts that are needed in quantities too small to be made by automated machinery.

**Assembly.** After a machine's parts have been made, assemblers and fabricators put them together. Some assemblers specialize in one stage of the process; others, such as team assemblers, work as a group and might contribute to an entire subassembly process. Despite

increased automation in the assembly process, many product parts still have to be put together and fastened by hand.

Painting workers finish an assembled product by applying paint or a protective coating to the exterior of the machine.

**Oversight.** The production process is directed by industrial production managers, who watch over all activities on the factory floor. First-line supervisors and managers of production and operating workers oversee all workers in the production process and ensure that equipment and supplies are available when needed.

Quality control is a responsibility of all production workers, but it is the primary focus for inspectors, testers, samplers, and weighers. These workers monitor the entire production process, making sure that both individual parts and the finished product meet the company's standards.

### Other work

Workers in other occupations provide support to machinery manufacturing production. These support occupations are related to production and sales activities.

**Production-related support.** Industrial machinery installation, repair, and maintenance workers are skilled

mechanics. They make sure that all of the machines and other equipment used in the production process function properly and are serviced regularly.

Production, planning, and expediting clerks create records and reports related to production, such as materials and parts used, products manufactured, and defects encountered. They also make sure that customer orders are completed, deliveries are scheduled, and shipments are made on time.

Purchasing agents use data from production, planning, and expediting clerks to procure the supplies that are needed in production.

**Sales workers.** Sales representatives and sales engineers often work together to market a company's machines to potential buyers. They demonstrate how a machine might reduce costs or increase sales, explain how to operate it, and answer clients' questions.

Sales engineers, in particular, use their technical background to tell clients how a machine would be useful to them and to suggest custom designs or equipment modifications as needed.

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## Machines and the industry that makes them

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The machinery manufacturing industry is divided into seven segments, according to the type of machinery produced. The industry includes both large and small workplaces, and the size of the workplace can affect how workers do their jobs. Workers also are affected by the evolving techniques that have propelled manufacturing into the 21st century.

### Types of machinery

The main types of machinery are special purpose and general purpose. Three segments of the machinery manufacturing segment make special-purpose machinery that is designed for use in a particular industry. Four industry segments make general-purpose machinery that is used by many different industries.

**Special purpose.** The special-purpose segments in this industry are agriculture, construction, and mining machinery manufacturing; industrial machinery manufacturing; and commercial



Photo courtesy of the Society of Manufacturing Engineers

Workers in this industry create metal parts using milling machines (above), drills, lathes, and grinders.

*Liquid cooling keeps machinery parts from overheating.*

and service machinery manufacturing.

The agriculture, construction, and mining machinery manufacturing industry segment produces both large, sophisticated machines and common household equipment. Examples include farm combines, large self-propelled machines that harvest and thresh grain; bulldozers and backhoes, used in building and road construction; grinders and borers, used for both surface and underground mining; and oil and gas field drilling machinery and derricks, used for extracting natural resources. This segment also makes lawnmowers, leaf blowers, and other lawn and garden equipment for residential and commercial use.

The industrial machinery manufacturing industry segment makes the machinery that is used to produce finished goods from raw materials. Wood, plastics, rubber, paper, textiles, food, glass, and oil are among the materials processed by this segment's machinery. Machinery manufactured in this segment also is used in printing and bookbinding and in making semiconductors and circuit boards.

The commercial and service machinery manufacturing industry segment produces the machinery that is used by firms that provide services. For example, firms make commercial versions of household appliances such as washing machines used in Laundromats, coffee makers and microwave ovens used by restaurants, and vacuum cleaners used by cleaning services. Other large employers in this industry are manufacturers of automatic vending machines; nonelectronic office machinery, such as typewriters and mail sorters; nondigital cameras; photocopiers; and machinery used to make optical lenses.

**General purpose.** The general-purpose segments in this industry are ventilation, heating, air-conditioning, and commercial refrigeration equipment manufacturing; metalworking machinery manufacturing; engine, turbine, and power transmission equipment manufacturing; and other general-purpose machinery manufacturing.

The ventilation, heating, air-conditioning, and commercial refrigeration equipment manufacturing segment makes climate-control machinery for residential and commercial buildings. This industry also makes air-purification equipment, which is increasingly common in new construction, and commercial refrigeration equip-

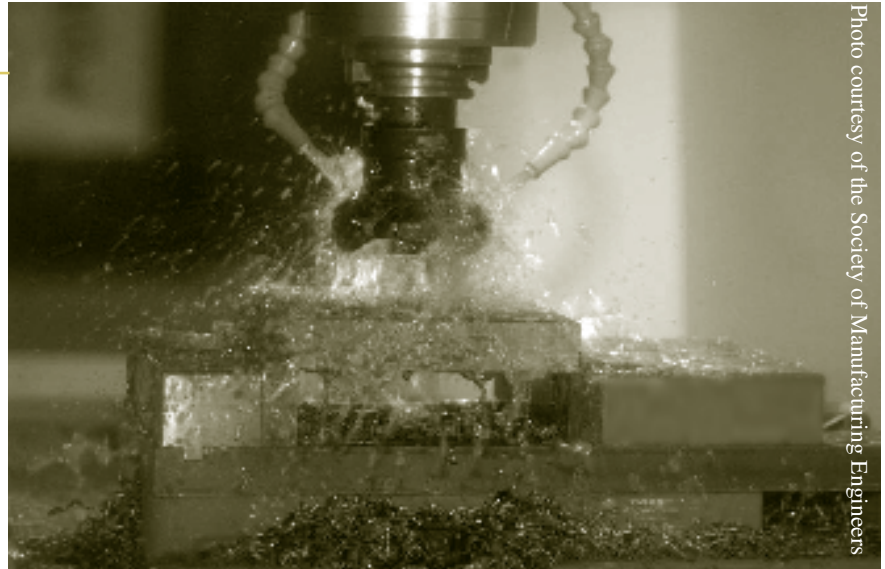


Photo courtesy of the Society of Manufacturing Engineers

ment used primarily for food storage.

The metalworking machinery segment makes machinery that forms metal in its molten state and that cuts or shapes metal as a solid. Although growth in the use of plastics has reduced the prevalence of metals, a wide variety of products have some metal parts, all of which have to be precisely formed from raw metal. The same properties that make metal a desirable component—strength and durability—also make it a difficult material to form. The drills, grinders, molds, presses, and rollers needed to form metal, as well as the accessories used by these machines, are made by this industry.

The engine, turbine, and power transmission equipment manufacturing segment includes a variety of machines that transfer one type of work into another. Turbines use the energy from the motion of steam, gas, water, or wind to create mechanical power by turning a drive shaft. Along with gears, speed changers, clutches, drive chains, and pulleys—all also made in this segment—turbines put assembly lines and other industrial machinery in motion; attached to a generator, turbines create electrical power. This industry segment also produces diesel and other internal combustion engines—except those used in automobiles—and their components, which are used to run portable generators, air compressors, pumps, and other equipment.

The other general-purpose machinery manufacturing segment produces miscellaneous machines used primarily by manufacturing industries. These include pumps, compressors, welding and soldering equipment, and packaging machinery. This segment also makes a variety of materials handling equipment—such as industrial trucks and tractors, overhead cranes and hoists, conveyors, and many types of hydraulic equipment—that is used

in manufacturing and other industries. Other common machinery produced by this segment includes scales and balances, power-driven handtools, elevators, escalators, and moving walkways.

The machinery manufacturing industry also includes companies that make parts for larger manufacturers. Making some of these parts requires specialized skills, and the parts are then sold to a variety of manufacturers. Companies contract with these parts manufacturers because doing so is often cheaper than making the parts themselves. Many of these parts are small and easy to transport—characteristics that make them easier for foreign competitors to produce and sell.

**Workplace size.** There were about 32,350 establishments, or workplaces, in the industry in 2004. About half of these establishments employed only 1 or a few workers, and half employed 100 workers or more. Most workers (59 percent) in the industry were employed in these larger establishments.

In general, the larger and more complicated the machinery is, the larger the manufacturing facility and the greater the number of workers needed to produce it. Thus, workers in the agriculture, construction, and mining machinery segment and the ventilation, heating, air-conditioning, and commercial refrigeration equipment segment are especially likely to work in large establishments. The metal-working machinery segment, in contrast, has more small establishments than any other segment in the entire industry.

The size of an establishment affects how some machinery is produced. Large firms usually have a multi-stage production process, with separate teams of workers responsible for design and testing, for manufacture of parts, and for assembly of the finished product. Nevertheless, the different types of workers often interact and work together; for example, design offices are often located near the factory floor to make it easier for engineers

and designers to talk with production workers.

Small establishments, conversely, might have a handful of workers who are responsible for the entire production process.

### **An evolving industry**

Like all U.S. manufacturers, machinery manufacturers continue to evolve. Domestic and foreign competition has led the industry to adopt new technologies and techniques to lower costs and raise productivity. For example, high-technology production techniques—including the use of robots, computers, and programmable equipment—have increased the amount that each worker can produce. At the same time, technology has increased the level of skill that workers need.

Pressures to reduce costs and maximize profits have led machinery manufacturers to adopt new business practices, too. One example is the increasingly common practice of using contract workers for warehouse and shipping jobs and support services, such as janitorial, security, and some administrative services. Contracting workers, instead of employing them directly, allows manufacturers to focus on design and production and increases manufacturers' flexibility. Employers can add and subtract contract workers more easily than they could hire and fire employees.



Photo courtesy of the National Tooling and Machining Association

### **Hours, earnings, and worklife in a high-tech factory**

As with nearly any job in any industry, working in the machinery manufacturing industry has advantages and disadvantages. Working conditions for production workers in the industry today are much improved from those in the past. Earnings are relatively high, and factories are much cleaner and safer than before. Some working conditions are still unpleasant, however.



## Benefits

The typical image of a factory—a huge, poorly lit room filled with noisy machines in which workers toil on an assembly line—is largely a thing of the past. In this industry, new facilities are especially comfortable: clean, well lit, and temperature controlled. Most of the labor-intensive work is now automated, but workers in some occupations may need to do heavy lifting.

Most workers in machinery manufacturing log 8-hour shifts, 5 days a week. Some facilities are capable of operating 24 hours a day, but some shifts are able to operate with a reduced workforce because of the automated nature of the production process.

Primarily because of their high productivity, workers in the machinery manufacturing industry enjoy relatively high earnings. In 2004, according to BLS, median weekly earnings for production workers in machinery manufacturing were \$700, compared with \$659 for manufacturing industries as a whole and \$529 for all industries. So, for many occupations, average earnings are higher in the machinery manufacturing industry than they are in other industries. For example, for most of the occupations in the table on page 5, workers in the machinery manufacturing industry average higher earnings than do other workers.

Individual workers' earnings vary for a number of reasons, including a worker's occupation and experience and the establishment's size. Many workers also have the opportunity to earn higher wages by working overtime.

## Drawbacks

Conditions have improved in machinery manufacturing, but the work does have some drawbacks. Noise is still a factor in machinery manufacturing, especially in large production facilities. And some workers must work with oil and grease or chemicals that require special handling. Certain types of machinery also require special care in their use.

Nevertheless, injuries are rare when proper safety procedures are observed. In 2003, according to BLS, there were 6.4 cases of work-related injuries or illnesses per 100 workers, compared with an average of 6.0 cases across all manufacturing industries. The rate for the pri-

vate sector as a whole was 4.7 cases.

Also, the seeming regularity of shift work does not necessarily guarantee 40-hour workweeks. Overtime is common in machinery manufacturing, especially during peak demand periods. About 34 percent of workers averaged more than 40 hours a week in 2004.

## Getting in and moving up: Training and advancement

Production workers in machinery manufacturing need a higher level of skill today than ever before. Nearly all jobs in this industry require that entry-level workers have at least a high school diploma. Employers also seek people who have good communication and problem-solving skills, both of which contribute to potential workers' versatility. Strong basic mathematics skills also are essential.

Skilled production workers, such as tool and die makers and machinists, almost always have previous experience or have completed a training program at a local college. Some companies also train entry-level workers in apprenticeship programs that last between 1 and 5 years, depending on the specialty. These programs combine on-the-job training with classroom instruction, either at the company or at a local technical school. Apprentices learn mechanical drawing, tool design, programming of computer-controlled machines, blueprint reading, mathematics, hydraulics, and electronics; workers also learn about company policies on quality control, safety, and communications. Apprentices are paid while they learn, and their wages increase as they gain skills.

Experienced workers may advance into higher skilled



positions within their field or into supervisory positions. Because advancement is based on experience and merit, workers who enter low-skilled positions can advance to higher skilled jobs by working to improve their skills.

Management and professional occupations generally require workers who have a bachelor's degree in their particular field, although some management positions are filled by experienced production workers. Most engineering jobs in the industry require that workers have a degree in mechanical or electrical engineering or one of their subspecialties. Because engineers usually are familiar with both design and production issues within a company, they may be able to advance into upper management positions.



Photo courtesy of the National Tooling and Machining Association

Demand for machinery is expected to remain strong because machinery boosts industrial productivity and because advances in technology will make machinery even more efficient and desirable. Demand for machines will continue to be sensitive to cyclical swings in the economy, however, and so employment in machinery manufacturing is expected to fluctuate with the economic recessions and expansions. When economic growth slows,

many companies are reluctant to purchase new machinery. Slowing demand often causes machinery manufacturers to lay off some workers or to replace fewer of the workers who leave.

As the world economy becomes more interconnected, machinery manufacturing, like other manufacturing industries, faces increasing competition from foreign producers. Most finished machines are made in the United States.

But increasingly, some machine parts are made in other countries and then shipped to U.S. manufacturers for final assembly. Although this practice currently accounts for only a small part of the total machinery manufacturing process, it has been a factor in recent employment declines.

But competition also spurs creativity—and machinery manufacturers' desire to do more with less, especially during lean times, could create opportunities in some occupations. Engineers, for example, are expected to have good prospects because their work focuses on boosting innovation and competitiveness in the industry.

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## Where the jobs are

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Although the total level of employment has fallen in recent years, there are still many opportunities in the machinery manufacturing industry, both for workers who are already highly skilled and for those who have the solid basic skills that make them good candidates for training. People who have completed vocational training courses or apprenticeship programs are particularly sought after by companies.

Machinery manufacturing jobs are located throughout the country but are more concentrated in some States. In 2004, about one-third of all jobs were located in the Midwestern States of Illinois, Indiana, Michigan, Ohio, and Wisconsin. Populous States, such as California, New York, Pennsylvania, and Texas, also had numerous jobs.

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## For more information

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To learn more about the machinery manufacturing industry or about the occupations in it, visit a library or career

counseling office. Look for books, trade journals, and other resources that provide detailed information.

One such resource available in most libraries and many career counseling offices is the *Occupational Outlook Handbook*. Among the hundreds of occupations described in detail are more than a dozen from the machinery manufacturing industry, including assemblers and fabricators; engineers; industrial production managers; inspectors, testers, sorters, samplers, and weighers; and machinists. The *Handbook* is also online at [www.bls.gov/oco](http://www.bls.gov/oco).

For many of the occupations in this industry, people can train in an apprenticeship. The summer 2002 issue of the *Quarterly* includes an article that explains how to find and apply for apprenticeships. The article is available online at [www.bls.gov/opub/ooq/2002/summer/art01.pdf](http://www.bls.gov/opub/ooq/2002/summer/art01.pdf).

Additional information about specific employment and training opportunities in the industry is available from State workforce offices or the employment offices of machinery manufacturing firms.

Entry-level employment and training information also is available from labor unions that are affiliated with machinery manufacturing occupations. Major unions include the International Association of Machinists and Aerospace Workers of America (IAM), the International Brotherhood of Electrical Workers (IBEW), and the United Automobile, Aerospace, and Agricultural Implement Workers of America (UAW). Check your telephone book's business listings for local chapter contact information. 

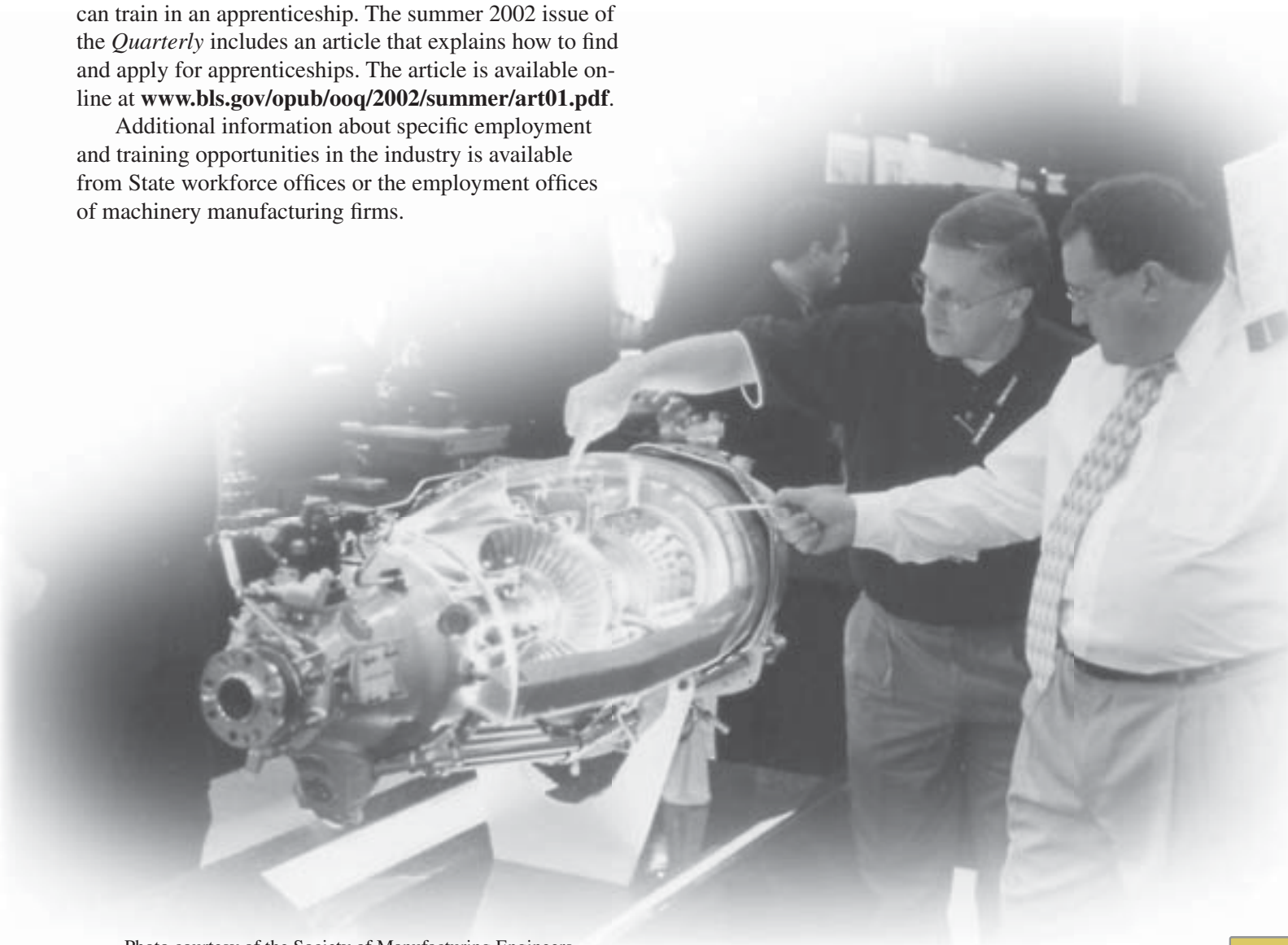


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