Transforming energy for industrial use: laser revolution in U.S. productivity

by Marsha Freeman

Over the next decade, an array of technologies in basic industry could increase American productivity at least four-fold. These technologies, in metal working, energy conversion, and materials processing, depend upon *directed energy*.

Today's basic industry uses energy primarily in the form of heat—the most dispersed form available. It is possible and more efficient, however, to apply the specific energy required by a particular industrial process, rather than bombard it with a large amount of gross thermal energy.

We produce our universal electric power, today's form of directed energy, using huge rotating equipment, suffering a loss of two-thirds of the energy converting heat from fuel to electricity. And, for hundreds of years man has produced machines largely by cutting, machining and shaping them with other pieces of metal. Today's machine shops are noisy, hot, and labor intensive.

But by using energy selectively, to a specific purpose, it will be possible to eliminate the use of "metal on metal" for basic manufacturing and replace clanking pieces of machinery with near-silent laser, electron beam, and plasma processes.

A revolution in metal-working

The first laser for industrial use was produced in 1966, a spinoff of research and development programs of the Department of Defense's first military rangefinder. More than 4,000 lasers are in use in industry. The machine-tool industry uses low-power lasers, under one watt, to calibrate numerically controlled machine tools and make sure they are doing precisely what they were designed to do. Hewlett Packard Company reports cases of 100 percent improvement in productivity when laser calibration is used to correct otherwise undetectable minor variations in straightness in the machinery.

Carbon dioxide lasers in the multiple-watt to kilowatt range are being used in many industries to drill, weld, cut, machine, and heat treat a wide variety of materials. Lasers today drill holes in nipples of rubber baby bottles, in plastic irrigation piping, and in cardboard for perforation.

Laser are cutting sheet metal to produce gears and other parts, and applied to plastics, textiles, glass, and paper. Lasers in pulses of a million a second cut holes in cigarette paper. Experts in the laser field estimate that at least 25 percent of U.S. industry's sheet metal cutting could be replaced by laser cutting, with a resulting 5- to 10-fold increase in productivity.

Drilling and boring done by machine tool and machinery builders could make use of laser technology; an estimated 20 to 30 percent of these operations could be replaced by lasers. The resulting productivity increases would be in the range of five-fold.

Laser welding is an emerging technology which is faster, more precise, and less intrusive than submerged arc and other conventional welding. In general, laser welding uses only two-thirds the energy of conventional processes. Three-quarters of today's spot welding could be replaced with laser welding stations, resulting in a three-fold increase in productivity.

Laser structural welding, including the welding of large plate steel pieces such as those used in shipbuilding, will be used, as higher powered, kilowatt lasers are made economical. At least half of today's structural welding could be done by lasers over the next five years, and productivity would leap 5- to 10-fold.

The U.S. Naval Sea Systems Command in Minneapolis has recently sponsored a program, "Laser Welding of Mild Steel," to develop more advanced manufacturing technology for defense materiel. A kilowatt laser replaced the submerged arc welding technique, and produced a 17-fold increase in productivity at decreased cost. The laser only required one pass through the material—arc welding had required seven. The Navy reports that $357,189 was saved on 1,200 welds, and that in the future the experimental laser system will be used in hardening, cladding, alloying, and cutting.

Soviet laser experts report they are using kilowatt-powered laser systems shipbuilding welding. United Technologies has used a 200 kilowatt laser to weld submarine parts two inches thick; this process will be applied to commercial shipbuilding.

One of the most promising laser uses is in metal surface treatment. Laser heat treatment for strengthening is in limited use, and replaces the need to put an entire part into an oven by delivering a beam of laser energy to only the specific surface that requires heat treatment. The Illinois Institute of Technology laser center reports that laser heat treating of large gears, rather than carbonizing them, which takes nearly an entire day, costs about 20 cents a gear, compared to a dollar for the conventional method. The laser process takes minutes.

Lasers can also be used for surface alloying and cladding. Nuclear power plant fuel rods and other metal exposed to hostile environments often do not need their entire parts ma of high-strength or non-corrosive alloys. The surface of the metal can be coated with a thin layer of the expensive alloy by a laser, rather than the bulk alloying done by today's technology.

High-powered lasers, in the multi-kilowatt to megawatt (million watt) range will do large-scale heat treating, cladding, and alloying of surfaces. Experts project that fully half of the work in the field of surface treatment could be replaced with lasers, with a two- to three-fold productivity increase, or more.

Why lasers boost productivity

The productivity increases with laser metal-working results from, first, the impossibility of wearing out a laser. Down-time to sharpen steel tools and replace them is eliminated; the laser can run continuously as long as it has materials to work on. Second, if the laser is combined with the simplest computer control, one worker can supervise more than one laser machine station.

Because the laser is cutting or drilling or welding more precisely than any steel-on-steel machine, fewer—if any—steps are required after its use to clean rough edges. A laser generates less waste and uses less material per part produced, with significant savings.

These savings are also obtained using laser machining which can replace a wide variety of mechanical devices. It is estimated that 20 to 30 percent of U.S. metal machining could make use of laser technology.

First-generation lasers in primary capital goods

For the purpose of modeling the increase in productivity in the capital goods sector with introduction of laser technology, we have assumed that 50 percent of the nation's capital stock in the machine-tool and machinery-producing sector will be replaced by lasers in the next five years. To make this possible, the laser industry will have to move from its handicraft assembling methods to mass production. Engineers involved this problem have devised designs for kilowatt-sized lasers which would make them amenable to assembly line production. These redesigned lasers have the potential to drop the cost from today's $35 to $40 per watt of installed laser capacity to perhaps only $10 per watt.

At that price, the laser machine tool would become competitive with conventional machinery and could be introduced into virtually every machine shop in the country, considering the expected return on investment that would accrue from the productivity increases.

The laser manufacturing facility needed to produce 25,000 industrial lasers in the next two years, would use the laser itself as a flexible machine. Therefore, this would be a self-replicating factory, since the factory would use lasers to produce lasers. The facility would need the basic laser station—a numerically controlled milling machine, a lathe, and a diamond machining station for the laser's optics.

Diamond machining itself has the potential to drop the cost of laser mirrors from $400-to-$500 today to perhaps $100. Automated assembly of the power supplies needed for the laser system would have to be developed and could be supplied out-of-house from smaller companies. Each automated facility would cost about $75 million, and could turn out 500 lasers a year. Developers point out that the hundred kilowatt-range industrial laser is about the same size and complexity of an experimental automobile, and could be produced on an assembly line in about the same time.

Computerized laser flexible machining

After the first five-year introduction of today's lasers in the metal-working industry, lasers will increasingly be combined with robotic stations to produce the factory of the future. This facility will require virtually no people for day-to-day operation. Computers will give directions to lasers that which will perform the majority of the processing functions; and computer-controlled robotic systems will keep the laser machining station supplied and handle all of the products.

This concept of laser flexible machining sees the laser as the universal machine, which could, in the same production cycle, cut, heat treat, surface alloy, weld, and drill holes. About 80 percent of the metal manufacturing done in this country could eventually be replaced by computerized laser flexible machining.

The Japanese Ministry of International Trade and Industry (MITI) is spending $57 million on a seven-year program to develop flexible machining with a laser. Twenty Japanese companies are sharing in this R&D program with the goal of developing a system to build machine subassemblies weighing up to 1,100 pounds in lots of 300.

The Illinois Institute of Technology laser center is developing multi-beam laser flexible machining stations for use in Midwest heavy industry. General Electric and other robot manufacturers are also working to wed the laser to automatic control.

In 1982 Coherent, Inc., a manufacturer of industrial carbon dioxide lasers, reported in *Laser Focus* that it had demonstrated a prototype robotic laser welding system, welding M-1 tank turbine engine parts. The system welded 80 to 100 inches a minute with a two-pulsed laser system of 575 watts. The two welders were out of phase, so while one was welding, the robot was loading the other. The station ran unattended for eight hours, and produced superior parts. The U.S. Army Tank Command estimated that $4 million will be saved using this robotic laser system for 8,000 tank units.

Over the next decade, laser-robotic combinations will replace whole factories, and link the most advanced manufacturing technique to the computer control which has existed for decades.

A full report on the economic impact of lasers is available from EIR Special Services: "The Economic Impact of the Relativistic Beam Technology," $250. Call 212-247-8820.