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Just add **batteries**: Cordless tools offer many advantages for assemblers. Recent developments in clutches and **battery** technology make them more appealing than ever. (**Power Tools**).

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Back in the 1960s and 1970s, waking up on Christmas morning without enough C or D **batteries** needed to operate the latest gee-whiz toys was every parent's worst nightmare. That problem was solved when toy designers and engineers began using small, lightweight nickel-cadmium **batteries** to power motors, lights, bells, buzzers and other delights.

Instead of forcing parents to pry four or more bulky lead-acid **batteries** into a hard-to-open compartment, today's toys typically operate on just one tiny **battery** with much higher power capacity. Better yet, the **battery** is typically built right into the toy, eliminating frantic last-minute runs to the store.

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A similar development period has occurred with **battery**-powered industrial tools. When screwdrivers, nutrunners, impact wrenches and other cordless fastening devices first appeared 20 years ago, they used heavy **battery** packs that generated low amounts of torque and repeatability. Because the tools were slow and awkward to use, they had no appeal in production environments. In fact, the first generations of cordless tools were laughed at by most people outside the construction, maintenance and do-it-yourself arenas.

But, after recent improvements in **battery** efficiency and clutch performance, assemblers can now choose from a variety of cordless tools that perform as well as air- and electric-powered alternatives. After years of widespread use in the construction industry, cordless technology is ready for prime time on the plant floor. There is increasing awareness and demand in the industrial market. And tool manufacturers are unveiling a wide variety of cordless products aimed at specific assembly applications.

Indeed, interest in the **battery**-powered tool market has picked up and was evident at last month's ASSEMBLY Technology Expo in Rosemont, IL.

Aimco (Portland, OR) announced that it will be rolling out a line of 20 **battery**-powered assembly tools during the first quarter of 2002 with numerous clutch styles, torque ranges and tool configurations. Bosch Production Tools (Addison, IL) also unveiled six models of cordless screwdrivers with a wide variety of options.

Makita U.S.A. Inc. (LaMirada, CA) plans to launch a dedicated line of 15 cordless assembly tools early in the new year. With other tool manufacturers claiming to be watching the market very closely, additional products may soon be available to address the unique needs of assemblers.

Free at Last

Today, cordless tools are more popular than ever. "The cordless market has grown by more than 10 percent per year over the last several years," claims Dave Selby, business unit manager for cordless products at Milwaukee Electric Tool Corp. (Brookfield, WI). "That's twice as fast as the tool market in general."

Cordless, **battery**-powered tools offer unique advantages for assemblers.

For instance, they can fit in tight spaces where an umbilical, such as an air hose or electrical cord, may restrict easy access and maneuverability. They also help eliminate headaches on the plant floor associated with cords, cables and hoses.

Air hoses and electrical cords stretched across a work area pose trip hazards. In addition, they consume valuable production time, especially when an operator has to detangle a cord or hose when it gets snagged on workstations, parts bins, fixtures, tool carts and other items.

Cordless tools allow assemblers to work easily on platforms, overhead lifts and other awkward places where space is at a premium and where taut cords or hoses can drag on tools. Operators can freely walk up and down an assembly line without worrying about dragging an umbilical behind them. "It's easy to change setups and [move] over to another area when you don't have to worry about air lines," says Selby. "The tools travel with the operator."

Some automakers are equipping their assemblers with holsters so they can whip out a tool when they see a loose fastener and correct the problem before the vehicle leaves the line. **Battery**-powered tools also help manufacturers address other quality concerns.

Cords and hoses that snag on corners or sharp edges can break off key parts or components. Wayward cords and hoses can scratch or mar the paint or surface finish of a product being assembled. Cords, cables and hoses dragging on a floor can pick up dirt, dust, oil and other contaminants. That's a big concern of companies that assemble high-ticket items, such as luxury cars, where preserving cosmetic appearance is very important.

"I make a lot of visits to job sites and the requests are for everything that has a cord to become cordless," says Mike Kirby, product manager for cordless products at Milwaukee Electric. "People want the freedom to move about the job without dragging a cord behind them."

"Cordless tools will replace any corded tools when they can perform at an equal level," predicts Kirby. "With the way technologies are advancing, this may come sooner than we think. Run-times have increased and these tools are more powerful than their cordless cousins from a few years back."

Cordless tools are not new. They were originally developed by the U.S. space program in the 1960s for making emergency repairs in orbit. Apollo astronauts also used **battery**-powered tools to drill beneath the moon's surface to collect core samples. More recent out-of-this-world applications for cordless tools include assembling the Hubble Space Telescope and the International Space Station.

Out of This World

The Goddard Space Flight Center (Greenbelt, MD) has developed what it considers to be the ultimate **battery**-powered tool. Its pistol grip tool (PGT) uses a microprocessor to control driving torque, angular speed and turn angle. The microprocessor also monitors the physical condition of the tool, which uses a 28-volt brushless DC motor with samarium cobalt magnets on the rotor. Performance data can be downloaded via serial interface for statistical process control.

The torque wrench is currently being used by astronauts during spacewalks and other extra vehicular activity required to assemble the \$27 billion International Space Station. Prescribed sequences of events can be programmed into the tool to ensure that no fasteners are overtorqued and that all are turned within specifications. Operators receive feedback via LEDs and an alphanumeric display.

Another unique aspect of the PGT is its **battery**. The tool currently uses a nickel-metal hydride **battery**, but it will soon use a lithium-ion cell that stores two to three times more electrical energy than traditional rechargeable **batteries**. The energy density of the lithium-ion **battery** will allow for a 36-volt **battery** in the same volume as a commercial 14.4-volt nickel-cadmium **battery**. It will be able to undergo more than 1,400 charge-discharge cycles, compared to the 400 and 500 charge discharge cycles exhibited by current generations of nickel-cadmium and nickel-metal hydride **batteries**.

Through its technology transfer program, the National Aeronautics and Space Administration (NASA) is attempting to find commercial applications for the PGT. But, the tool has an out-of-this-world price tag.

Some tool manufacturers have expressed an interest in parts of the state-of-the-art device. "We're intrigued by brushless motor technology," says Mike Gorman, product manager of DeWalt Industrial Tool

Co. (Baltimore). "There's definitely some opportunities for further innovation aimed at creating more torque output.

Back on Earth, **battery**-powered tools have been commercially available for more than 15 years. Until recently, assemblers who wanted to use cordless technology on the plant floor had to rely on tools designed for the do-it-yourself and construction markets.

Many of those tools featured a relatively low power-to-weight ratio and typically supported low-torque, low duty-cycle applications. Accuracy, torque and repeatability were inadequate for most assembly applications. In addition, convenience and portability were offset by relatively low **battery** life cycles.

Recent developments in tooling and **battery** technology, however, promise to spur demand on the factory floor. After years of taking a back seat to air-powered and corded electric tools, cordless tools finally appear to be on the verge of widespread use in production environments.

"Today, there's definitely a strong case for considering cordless tools," says Vince Caito, marketing communications manager for Makita. Although his company was a pioneer in the **battery**-powered tool market, it traditionally concentrated much of its focus on the construction industry. Now, it's getting ready to branch out and launch a line of fastening tools dedicated to assembly tasks.

According to Caito, new environmentally friendly **batteries** and more **battery** recycling programs are spurring demand for cordless tools. "Nickel-metal hydride **batteries** do not contain any harmful cadmium," says Caito. "There's also a much better awareness now about **battery** recycling." For instance, the Rechargeable **Battery** Recycling Corp. (RBRC, Atlanta) has established a nationwide network of more than 20,000 drop-off points. The RBRC is a nonprofit organization funded by manufacturers of portable rechargeable **batteries**. It has developed a special label that is affixed to **batteries** urging cordless power tool users to recycle.

"Advancements in rechargeable **batteries** and charger technology are the leading reasons why cordless power tools are becoming more popular," claims Milwaukee Electric's Kirby. "**Battery** technology continues to advance. Over the past few years, **battery** manufacturers have been finding new technologies making it possible to get more energy into the cells, which in turn allows for longer run-times."

Indeed, the average life of the typical nickel-cadmium **battery** pack has increased from 2 to 2.4 amp-hours. Early nickel-cadmium **batteries**, by contrast, were often rated at only 1.2 or 1.4 amp-hours.

New **battery** technologies, such as nickel-metal hydride and lithium-ion, are boosting run times even further. Advancements in nickel-metal hydride **battery** packs have increased dramatically in the past few years. While nickel-cadmium **batteries** max out at 2.4 amp-hours, nickel-metal hydride cells currently run up to 3.3 amp-hours. The energy

density in a nickel-metal hydride cell is twice that of a nickel-cadmium cell.

Lithium-ion **battery** technology is still being developed for power tool applications. While it is great for constant drain applications, such as notebook computers, it can't provide the peaks of power that tools need. "They are unable to deliver the high currents required by most cordless tools," Milwaukee Electric's Selby points out.

A New Generation

The new generation of industrial cordless tools also address accuracy, repeatability and torque. Features include optimum cut-off precision, repeat protection and overload protection. In addition, new electronic features make it easier for operators to use cordless tools. For example, many tools now feature built-in miniature spotlights positioned near the tool bit to illuminate the work area. The lights are activated whenever an operator engages the tool.

End users can obtain instant feedback via visual cues and audible signals that indicate **battery** condition, torque status and joint control. For instance, the Bosch Exact screwdriver features two parallel LEDs built in to the rear of the tool. The light on the right side indicates torque: green if it's correct and red if it's incorrect. If the desired shut-off of the clutch is not reached, the user also hears an audible beep.

The light on the left side warns the operator about the **battery**: a green flashing light signals that the **battery** can perform a few more screwdriving operations before it must be changed. When the tool can no longer reach correct torque, it shuts off and turns on a red light.

Many of the new cordless tools entering the assembly market retain a very high degree of repeatability regardless of the hardness or softness of a joint. "Conventional cordless tools used in the construction industry have a lock-over (ratcheting) clutch, which has a very wide torque tolerance," says William Staiger, major accounts manager at Bosch Production Tools.

"Some competitors use these conventional tool clutches to build a production tool," warns Staiger. "This is not acceptable for the production environment. Our shutoff clutches have a torque tolerance similar to DC electric smart tools. Our tools work at a minimum CMK of 1.67 (required by the European car industry) and in most cases, our tolerances are much tighter than that."

With right-angle attachments and different **battery** sizes, such as 9.6- or 12-volt cells, cordless tools can produce different torque and motor speeds. For instance, Bosch's new cordless tool line ranges from the Exact 2, which boasts a range of 0.6 to 2 newton-meters at 600 rpm with a 9.6-volt 1.7 amp-hour nickel-cadmium **battery** to the Exact 12, which features a range of 1.5 to 12 newton-meters at 400 rpm with a 12-volt 2.4 amp-hour **battery**.

"The difference in these models is rpm, torque and **battery** voltage," says Staiger. "We specifically developed these different versions based on customer requests. Bosch feels that accuracy is best maintained by having a wide range of versions to meet the specific torque demands of an application rather than try to do everything with one or two models. Since joint hardness is not an issue for us, the application can be anything desired within the range."

Market Demands

Aside from dramatic improvements in **battery** and clutch technology, three trends are also contributing to the growing popularity of cordless technology: rising energy costs, ergonomics and lean manufacturing.

Rising energy costs are a key concern for all manufacturers. According to a recent survey conducted by the National Association of Manufacturers (Washington, DC), 80 percent of small-and medium-sized manufacturers reported having lower profits during the past 12 months due to higher energy costs. Machine-drive applications, such as air tools, accounted for 22.1 percent

Rechargeable **Battery** Technologies

Nickel-cadmium

Most common type of rechargeable **battery** used for power tools. Technology has been commercially available since early 1980s. It uses cathodes made from nickel and anodes from cadmium. Can be recharged many hundreds of times. Cadmium is toxic and poses an environmental hazard, but nickel-cadmium **batteries** can be recycled.

Nickel-metal hydride

Considered the "next generation" of power for cordless tools. Technology has been commercially available since 1997. Rapidly becoming popular for power tool applications because it does not suffer from the memory effect that nickel-cadmium does. Increased energy density offers longer service life between charges. Lack of cadmium makes it environmentally friendly.

Lithium-ion

Offers very good power-to-weight ratio. Contains up to twice the energy density of nickel cadmium and nickel-metal hydride **batteries**. Often found in high-end laptop computers and cell phones. Still very expensive, which limits widespread use in cordless tool market of energy use, the second highest demand after process heating.

Pneumatic tools are not known for being energy efficient. Regulators are required to keep the line pressure constant, and the compressor has to keep running all the time.

The Department of Energy (Washington, DC) says compressed air systems account for 10 percent of all electricity use in the United States or 1.5 billion per year of total energy costs. As a result, many manufacturers are eager to find cost-effective alternatives to pneumatic tools.

"Air is expensive and tends to be a high fixed cost," notes Steve Bulleit, director of training at Aimco. "It takes a lot of electrical energy to compress air. **Battery** tools require none of the installation and maintenance costs associated with air tools, such as hoses, fittings, filters, regulators and moisture separators." A cordless tool only draws power when its **battery** is being recharged.

Pneumatic tools require a dedicated infrastructure to support the air lines. In today's flexible assembly environment, cordless tools allow manufacturer to avoid costly plant floor changes when production lines need to be reconfigured to meet changing market conditions.

Ergonomics is another factor that makes cordless technology very appealing to assemblers. A recent survey conducted by the North Carolina Ergonomic Resource Center (Raleigh, NC) discovered that ventilation and noise were two of the most frequently cited causes for worker discomfort. Because they don't vent air, cordless tools are generally quieter than pneumatic fastening devices. By avoiding oil spatter, they are also much cleaner to operate.

Many manufacturers are using tiltable fixtures and adjustable workstations to address ergonomic concerns. With all that extra movement, air hoses and electric cords can easily get tangled or snagged. Cordless tools give assemblers more mobility to move in, under and around the product being assembled. Of course, they also help reduce the risks associated with tripping over pesky cords and hoses.

The growing use of skillet conveyors in auto plants to reduce the risk of repetitive motion strains and back injuries is also boosting the need for cordless tools. A skillet conveyor is a closed-loop, friction-drive system with a floor-level palette capable of carrying one vehicle. The conveyor can be adjusted to optimize the relationship between the operator and the assembly tasks being performed. With a few easy adjustments, the conveyor height can be changed to match the physical characteristics of the operator working a specific shift, reducing the opportunity for strains, sprains and muscle fatigue.

Cordless fastening tools are available in either pistol-grip or inline designs. Most tools feature T-handle designs to evenly distribute the weight of the tool and the **battery**.

The lean manufacturing initiative sweeping the United States calls for the elimination of waste throughout the production process. Cordless technology proponents claim **battery**-powered tools are ideal for this type of environment.

"I'm starting to see more and more cordless tools," says Rick Harris, president of Harris Lean Systems Inc. (Stamping Ground, KY). "There are

some distinct applications where cordless technology may offer a clear advantage over air or corded tools. For example, the tool is always where the operator is. It's immediately ready and available."

Harris, coauthor of a new book entitled *Creating Continuous Flow* (Lean Enterprise Institute, Brookline, MA), previously served as manager of final vehicle assembly at Toyota Motor Manufacturing Inc. (Georgetown, KY). He says a key principle of lean manufacturing is to lay out workcells so one person can make one piece as efficiently as possible.

According to Harris, one of the basic guidelines for cell layout is to "keep tools as close as possible to the point of use and orient them in the direction that they are used by operators." He also recommends combining two or more tools whenever possible. "Cordless tools can cut down costs significantly," Harris claims, "because one tool can do the job of two or more."

Pros and Cons

Cordless technology is not for everyone. Indeed, many fastening applications are not appropriate for **battery**-powered tools, especially when a critical joint is required. And, despite numerous benefits, cordless devices can be inferior to other tool options, such as DC electric or pneumatic screwdrivers. Before deciding to go cordless, it's important to examine the pros and cons of each type of tool and your specific assembly application.

Although they are the most portable, **battery**-powered tools can be inconvenient and costly in terms of backup **battery** storage and the downtime involved in changing **battery** packs. Because **batteries** need to be replaced and recharged, cordless tools tend to require higher maintenance than other types of fastening tools.

According to Milwaukee Electric's Selby, cordless tools are more expensive than their corded counterparts. "But, when you purchase a cordless tool you typically receive the tool, one or two **battery** packs and a charger," he points out. "The initial purchase price is higher due to the cost of **batteries** and charger. **Batteries** make up a significant portion of the cost of a cordless tool, especially when manufacturers use high quality **batteries**."

By comparison, DC electric tools are much higher priced, but have the lowest total cost of ownership. Pneumatic tools are lower priced than DC tools, but they carry a higher total cost of ownership over the long term.

Accuracy and control are the main advantages of DC electric fastening tools. For instance, DC electric tools have built-in transducers and sophisticated electronics to measure and control torque.

Because air constantly blows through pneumatic tools, they tend to run cooler than electric tools and thus may be more appropriate for high-volume production. Indeed, electric tools may overheat if used constantly. For installing fasteners at very high torques—more than 400

newtonmeters--pneumatic tools are often better than electric tools. However, electric tools are quieter than comparable air tools because they don't vent air. Pneumatic tools also require a dedicated infrastructure to support the air lines, whereas electric tools just have to be plugged in.

"The drawback of DC electric tools is weight, price and the heavy, stiff power cable," argues Bosch Production Tools' Staiger. "Cordless tools are the lowest cost fastening device in the industry, if you evaluate running cost and initial investment. There are no high initial expenses as with DC tools, and there is no cost of compressed air over time as with pneumatic tools. Since production costs play an important role in corporate profits, this can be a major factor."

Bosch claims that its Exact screwdriver is the first cordless tool in North America to receive a seal of approval from Underwriters Laboratories Inc. (Northbrook, IL). Staiger believes that safety endorsement will give the product instant credibility from assemblers who have traditionally shied away from **battery**-powered tools.

"The clutch design is what affects repeatability on different joint types, and we feel that our shut-off clutches handle all types of joints very well," adds Staiger. "To us, cordless tools and many of our air tools are identical in accuracy and repeatability since they share the same clutch."

Aimco's Bulleit agrees that torque accuracy will be critical to the widespread acceptability of cordless tools in the assembly arena. He says his company's new line of **battery**-powered fastening tools will be capable of handling many different applications that demand both low and high torque. The tools will feature five different types of clutch combinations: driver-drill; slip clutch; shut-off clutch; pulse; and impact.

"Clutch design is the same for both our cordless and most of our pneumatic tools," Staiger points out. "Of course, a DC tool should be able to outperform most mechanical clutches in repeatability and accuracy, but we have seen cases where our mechanical clutch has equal or better accuracy and repeatability as compared to some DC products when measured by inline transducers.

"As a process engineer, you have to ask, 'How much will it cost to produce a quality product?' If you look at the costs of DC tools vs. the benefits, there is justification in many cases. But, if you can get that repeatability and accuracy from a tool that costs less than one tenth of what a DC tool costs and eliminate cables, what are you really gaining by going to DC? In the end, it's the quality of the joint that makes the vehicle have Less rattles, or keeps the washing machine from vibrating apart that keeps the end consumer loyal to the purchased product."

Textron Fastening Systems (Rockford, IL) has developed a cordless riveter that it claims is comparable to pneumatic tools when placing 3/16-inch blind rivets using a 12-volt **battery**. Mike Gray, product manager for hand tools, says the Avdel Cherry TX2000 **battery**-powered tool can place 38 rivets per minute. "That translates into 600 rivets

per charge," Gray points out. "At full stroke, the tool has an average cycle time of 2 seconds.

"Once operators have been exposed to what the cordless tool can do, they find that they can't live without it," claims Gray. "We're bullish on **battery** technology." He says Textron is planning to develop a line of cordless insert tools and speed-fastening tools.

Electric tools weigh 10 percent to 15 percent more than air tools. Traditionally, cordless tools have weighed heavier than air and electric-powered devices. Indeed, the typical **battery** adds more than 1 pound to the weight of a cordless tool. But, tool manufacturers are addressing that issue.

Hitachi Power Tools (Norcross, GA) recently unveiled a cordless impact wrench and driver that weigh only 3.7 pounds when equipped with a 12-volt, 2.0-amp-hour nickel-cadmium **battery**. According to Steve Caraga, vice president of sales and marketing, the tools, which produce 86.4 ft-lb of torque, are 33 percent lighter than previous models.

Part of the weight reduction is due to the use of carbon brushes in the motor and a die-cast aluminum housing. Hitachi also markets a 9.6-volt cordless impact wrench and driver that weigh 3.5 pounds each.

Some cordless tools are even lighter. For instance, the Accu-Tec screwdriver from Fein Power Tools Inc. (Pittsburgh) weighs only 2.8 pounds with a 9.6-volt **battery** attached.

Cordless Applications

Since rechargeable **battery** technology was commercialized in the early 1980s, shipments of cordless power tools have increased dramatically. A recent study conducted by the Freedonia Group (Cleveland) forecasts continued growth throughout this decade. Demand will grow 8.4 percent annually through 2004, when the market is expected to reach \$700 million.

By comparison, demand for corded electric tools will increase less than 2 percent annually during the next 3 years. The Freedonia Group market analysts claim the gains in cordless tool shipments will be fueled by advances in **battery** technology that allow for more powerful products with longer run times.

"Cordless tools have gone from occasional, nice to have products to core tools," notes DeWalt's Mike Gorman. He says the construction industry has traditionally been the biggest user of **battery**-powered tools. A wide variety of tools are available, such as circular saws, drills, grinders, planers, polishers, reciprocating saws, rotary hammers, sanders, scrapers and screwdrivers. In fact, it's possible to build an entire house today using only cordless tools.

But, as more tools find their way into the manufacturing world, assembly line applications are expected to blossom. Some observers claim

it's a trickle down effect. "The popularity of **battery**-powered tools in the construction and do-it-yourself markets is transcending into the production environment," says Textron's Gray. "We're already seeing widespread use of cordless technology on European assembly lines. That will eventually migrate to the United States."

Automotive OEMs and Tier One suppliers are showing the most interest in cordless tools. However, Boeing, Caterpillar and other large manufacturers have expressed a keen desire to eliminate or reduce the miles of air hoses in their factories by investing in cordless technology.

Cordless tools are extremely popular in Europe. "Audi and Mercedes-Benz use our cordless products for all types of interior and exterior trim applications," says Mark Mitchell, director of sales and marketing at Bosch Production Tools. For instance, he claims there are thousands of cordless tools in use at Audi's vast Ingolstadt, Germany, plant that assembles A3 and A4 sedans.

"There are complete sections of the assembly line that have no air hoses or DC cables," Mitchell claims. "This allows workers to operate in teams that stay with a single vehicle during a series of fastening processes rather than having a worker wait for the piece to come to him. It has completely changed the way they build a car." Mitchell says it's not unusual to see operators armed with cordless tools working inside cars as they move down the assembly line.

Lean manufacturing consultant Rick Harris confirms that it's difficult for automobile assemblers to maneuver air tools into the vehicle. "Most cordless applications involve installing trim screws in tight spots, such as underneath the dashboard," explains Harris. "I've also seen **battery**-powered tools used underneath vehicles, especially in areas where it's difficult to use a traditional fastening tool, such as the area around the gas tank."

Any fastening task that requires less than 12 newton-meters of torque is a potential application for cordless tools. Aimco's Bulleit says he's seen more and more furniture assemblers investing in cordless technology.

Security Concerns

Some manufacturers have been reluctant to invest in cordless tools because of security issues. They're afraid that the unique mobility of the tools will tempt workers to steal or "borrow" the devices. Unlike pneumatic tools, cordless devices can easily be used outside the plant floor. But, proponents of cordless technology claim the benefits of **battery**-powered tools outweigh those concerns.

"Anti-theft devices are technologically available, however not commonly offered due to the added cost," says Milwaukee Electric's Selby. "Most customers would shy away from the added cost."

He argues that security is an issue with all assembly tools, whether

they're powered by air, **batteries** or electricity, since most are compact in size, thus making them an easy target for theft. However, Selby admits that his company is considering building special sensors into its tools to help deter theft.

Another company experimenting with anti-theft devices is Textron Fastening Systems. "There's definitely a need for that type of feature with cordless tools," says Mike Gray. "We're looking into a special tool tracker. It would probably use an integrated chip that would sense when the tool leaves a central base. For example, if the tool was more than 500 feet from the spot, some sort of alarm would be activated."

In the wake of the recent terrorist attacks in New York and Washington, DC, and a tragic shooting incident earlier this year inside a Navistar engine assembly plant near Chicago, more manufacturers are beefing up security measures. In some facilities, that tightened security involves placing metal detectors at all entrances. Some cordless tool experts say that would deter most operators from walking off with any type of tool.

Aimco's Steve Bulleit believes security is more of an issue if the tools being used are similar to what someone can buy at a local hardware store. "We don't have any built-in anti-theft features in our new line of cordless tools simply because all our products will be provided solely for the industrial market," says Bulleit.

Despite occasional security concerns, the current trend toward making cordless tools lighter and more compact is expected to continue. At the same time, pneumatic and DC electric tools will not disappear from assembly lines in the near future. In fact, some of the companies leading the charge to **battery** power, such as Aimco and Bosch, also make a full line of air-powered and corded electric fastening tools. But, cordless tools and **battery** chargers will become more common sites on the plant floor as assemblers gain more confidence in the technology.

Cordless Power Tool Shipments
in millions
1999 \$465
2004 \$695
2009 \$1,050

Note: Table made from bar graph

Power Tool
Battery Market
in millions

2000 \$220
2005 \$290
2010 \$390

Source: The Freedonia Group

Note: Table made from bar graph

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