Copper Development Association Inc.
Copper Alliance

Future-Proof Technology: How Advanced Machine Tools and Brass Empower Manufacturing Success

Introduction

Global competition and high demand have propelled manufacturing to rapid advances in productivity. Increased challenges accompany greater competition, including expanded production and reduced costs per part. With heightened demand for everything from electronics to new transportation infrastructure, manufacturers have sought new ways to keep pace with their industry segments. One solution to their need for increased production efficiencies lies in acquiring new, advanced high-speed machine tools. Many factors enter into the decision to invest in these new technologies – and the high-speed machining potential of materials such as brass makes it even easier for manufacturers to justify the cost of new equipment.

How the Economy Drives Advances in Machine Tools

Technological advancements can enable shops to enhance their competitiveness without adding new personnel, a critical consideration in light of the skilled labor shortage that leaves all industries scrambling to find qualified workers. New developments in machine tool capabilities, however, mean that shops not only can produce more parts with fewer pieces of equipment, but they can – and in many cases, must – redefine their workflows to match the demands of modern manufacturing.

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Modern machine tools incorporate more spindles than ever before, enabling the rapid fulfillment of large orders through simultaneous production of multiple parts. These same machines can accommodate small runs of parts, once operators master tooling and minimize setup time on new equipment. Shops can set up standardized tooling with tool presetters for optimal offsets, batch parts that share the same material stock and use other strategies to reduce cycle time, all thanks to multi-spindle equipment.

Along with increases in spindle capacity, today's machine tools also offer multi-axis capabilities that increase shops' design capabilities exponentially at the same time that they reduce setups and increase accuracy. A five-axis machine makes it possible to machine all five sides of a prismatic part in one setup and reduces the number of parts that require casting instead of machining. The same five-axis machine also speeds up production of simpler parts that would require multiple setups on three-axis equipment.

With direct-drive servomotors on rotary axes, today's machine tools also offer faster rotation without the backlash that gear-driven systems introduce. Those faster axial speeds further enhance production capacity while the motor technology increases the ability to perform the rapid acceleration/deceleration required for complex parts.

Many of these advanced machine tools either include automation as a standard feature or offer automation-ready designs, further simplifying setups and enabling shops to add shifts without increasing personnel. Machine tool manufacturers increasingly offer their customers built-in pallet changers, load-in options and other features that otherwise would require third-party add-on technology, all with service and warranty coverage from the manufacturer itself.

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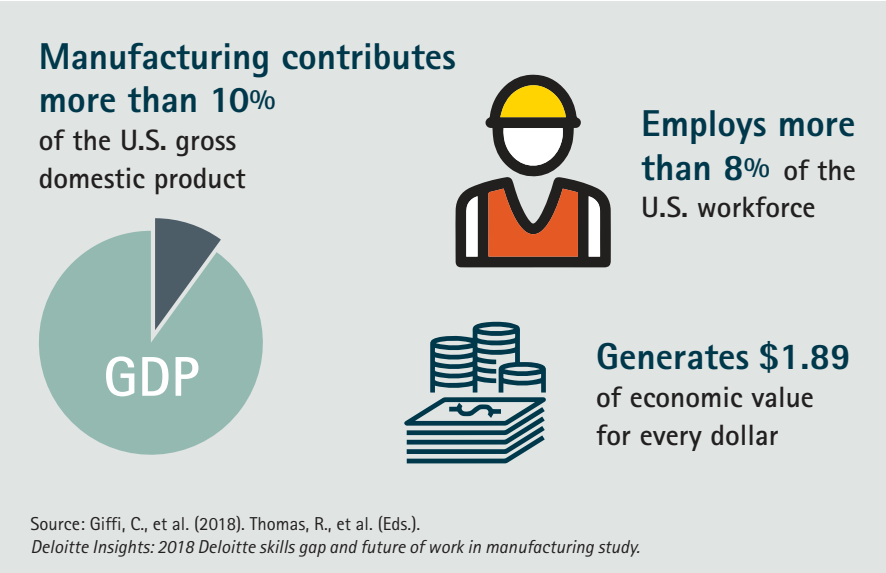
New manufacturing strategies also take full advantage of the capabilities of these advanced machine tools. Batch production enables shops to take on the smaller jobs that customers increasingly request, especially for products with tight tolerances and stringent specifications. As production strategies shift from the mass quantities of high-volume, low-mix (HVLM) assembly lines to high-mix, low-volume (HMLV) specialization, efficient new equipment with minimized setup time eases the transition to fulfilling orders that may call for single workpieces.

Along with the equipment on which it relies, every manufacturing firm operates within a larger context that also affects the way it does business – and the way it defines itself. Modern machine tools can help shops overcome some of the challenges that stem from their business environment, including personnel challenges.

Manufacturing contributes more than 10% of the U.S. gross domestic product, employs more than 8% of the U.S. workforce and generates $1.89 of economic value for every dollar invested. Between 2018 and 2028, however, manufacturers will need to fill 4.6 million vacant jobs, including 2.69 million positions that open as Baby Boomers retire and 1.96 million created through economic growth. Employers will be unable to find skilled workers to fill 53% of these jobs, leaving 2.4 million of them vacant. These persistent skills shortages could compromise $2.5 trillion in economic output over a 10-year period.



Source: Giffi, C., et al. (2018). Thomas, R., et al. (Eds.).
Deloitte Insights: 2018 Deloitte skills gap and future of work in manufacturing study.

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This skills gap stems from numerous trends and sources, but three facts in particular define its impact on manufacturing. As retirements increase, positions open that younger workers lack the ability or the willingness to fill. Outdated negative perceptions of manufacturing paint it as an intellectually unrewarding profession with dim, grimy workplaces, and that negative picture discourages younger workers from pursuing these careers. At the same time, the focus on college education also leads these young workers in career directions other than the manufacturing floor. Employers also have contributed to the problem, with a lack of focus on training their existing employees for greater opportunities.

The skills gap reduces the available labor pool, but enhanced automation-based productivity enables manufacturers to run more production processes with fewer workers. With the advent of conversational input and onscreen prompts that guide operators through what once constituted challenging setups, automation programming has become less technically demanding and more accessible to a broader range of personnel.

Additional external pressures alter the business landscape for manufacturers, including the growing use of expensive advanced materials with challenging production requirements. These materials require new tooling with even newer coatings, demand revised methods and procedures, and dominate industries with some of the most stringent specifications and tightest tolerances of all, including aerospace, automotive and medical manufacturing.

While manufacturers rethink their production processes to accommodate new workflows that handle demanding parts, they also must maintain a focus on environmental friendliness. From regulations that cover how they handle consumables to the desire to capitalize on the economic value of scrap material, today's manufacturing businesses face unprecedented environmental considerations. The production opportunities they choose to pursue reflect the choices they make about these fundamental issues.

Consumer demand also changes the manufacturing mix. The move toward HMLV production reflects an increasing focus on mass customization, which enables a purchaser to select options for many aspects of product functionality and appearance – and which further drives the need for HMLV to respond to what amount to ultra-small product batches within larger jobs. Increasing product sophistication demands greater production sophistication to create workpieces within tight tolerances.

Advantages of Modern Machine Tools

Modern machine tools can transform production for manufacturers large and small. With shorter setup and tool-change times – in part thanks to multi-axis capabilities – and the ability to produce a wider range of complex parts with more-demanding specifications, these new pieces of equipment can transform output capabilities. These machines' rigidity and stability, along with their high power, enable them to tackle hard-to-machine materials and produce greater workpiece accuracy. Along with production innovations and capacity increases, these new machine tools also make it easier for operators of all skill levels to master them successfully. Developments in conversational programming reduce the bar to entry for less-experienced personnel.

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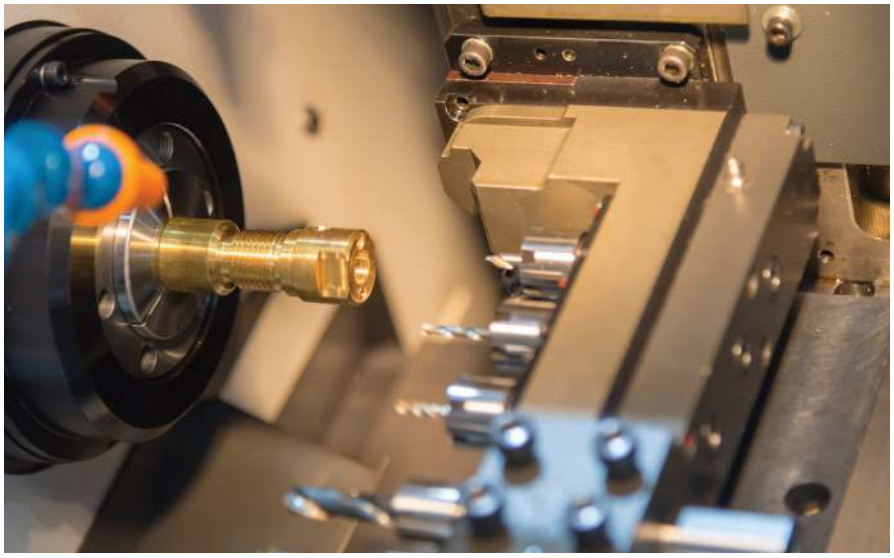

Investing in new machines also gives manufacturers an opportunity to retool for proactivity as well as productivity. Instead of acquiring only enough new speed and output to continue their current work with a small boost in capacity, manufacturers can look for equipment that will enable them to expand, taking on jobs that formerly lay outside their capabilities. If they continue to view capacity from the standpoint of their aging equipment, dependent on the expertise of a handful of experienced operators who know how to overcome its quirks, they will fail to consider that no amount of expertise can compensate for increasing down time, overly high scrap rates and a reliance on the skills of a workforce nearing retirement age.

Justifying the Cost of Machine Tool Investments

Advanced machine tools carry higher price tags than less-sophisticated equipment, leading many manufacturers to doubt the wisdom of these investments. They look at the number of simpler machines they could acquire for the same or less money, capable of producing nearly the same capacity, and they hesitate. If they view initial investment as their sole consideration, however, they take a shortsighted view that may stunt their future growth.

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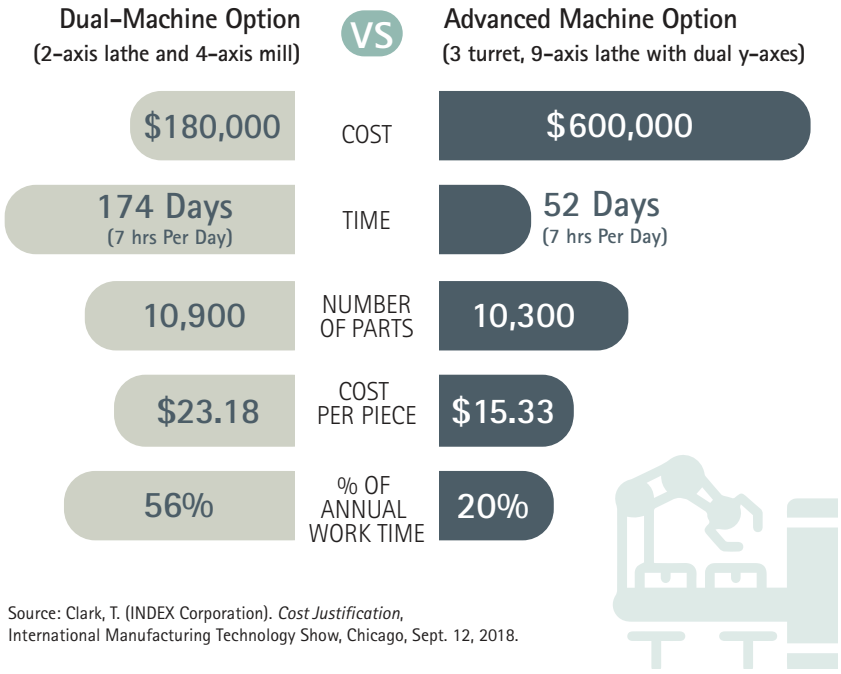
For example, suppose a manufacturer receives an order for 10,000 pieces per year of a connector housing. Should they tool up to produce it on two machines – a 2-axis lathe and a 4-axis mill – or should they acquire a 3-turret 9-axis lathe with dual Y axes that can handle the entire process on one piece of equipment? Both options use the same tooling, feeds and speeds, with a single operator required in each case.



Source: Clark, T. (INDEX Corporation). *Cost Justification*, International Manufacturing Technology Show, Chicago, Sept. 12, 2018.

Running seven hours out of each eight-hour day, the dual-machine option costs a total of $180,000 to purchase and produces 10,900 parts in 174 days of operation. To produce the 10,000 pieces required for the new contract, this option carries machine, labor and shop-rate costs that total $231,768, for a cost per piece of $23.18. The contract will take up 56% of the equipment's annual work time.

While the more-sophisticated machine carries a higher purchase price of $600,000, it produces 10,300 parts in only 52 days of run time. Its machine, labor and shop-rate costs for the new contract total $153,296, or $15.33 per piece, which is about 34% lower than the dual-machine option. At only 20% of the machine's annual work time, the multi-turret machine leaves 80% of its availability open for other work.

Additionally, opting for the second option eliminates the need to transfer parts between machines to complete them, which in turn increases production accuracy. With only one machine to schedule instead of two, the shop can simplify the process of meeting its contract terms. Now, with production capacity to spare, the new single machine leaves room for more work, including jobs on which the manufacturer formerly might have missed out. In general, increasing throughput can have a greater impact on shops' profitability than a lower machine purchase price, reduced labor requirements, longer tool life or reduced maintenance costs, among other factors.

At the same time that the new equipment offers the manufacturer **increased capacity,** its high-speed capabilities offer something just as important: the chance to tap into the productivity upside of highly machinable materials like brass that take full advantage of modern machine tools.

Brass, the Real Key to Productivity

With a machinability rating of 100%, brass lends itself to high-speed machining to a greater degree than perhaps any other metal. Contrary to conventional wisdom, manufacturers can – and should – run brass at the highest speeds and feeds that each machine tool safely allows.

If manufacturers follow the outdated recommendations in overly conservative handbooks, however, they will continue to underestimate the productivity of brass by up to 85%, and risk missing profits they could earn through high-speed machining.

In reality, brass readily supports high-speed production on today's advanced manufacturing equipment, often with little tool wear and excellent chip control, even after long periods of operation, which decreases downtime for tool changes. In fact, an extensive machinability study[1] recently demonstrated the remarkable cutting speeds and metal removal rates that can be achieved on brass rod alloys for practical production periods.

The optimized, high-speed metal removal rate comparison below illustrates the productivity upside of brass compared to steel and stainless steel and the impact on machining costs.

Machining speed and cost comparison[†]

	Turning		
	304L stainless steel	12L14 steel	Brass
Maximum Cutting Speed with Acceptable Tool Life (surface feet per minute; carbide inserts)	800	1,200	4,000
Optimized High-Speed Metal Removal Rate (in^3 per minute)	3.02	4.54	21.6
Machining Cost (per 1,000 in^3 of material removed at $100/hr.)	$550	$370	$80

	Drilling		
	304L stainless steel	12L14 steel	Brass
Maximum Cutting Speed with Acceptable Tool Life (surface feet per minute; carbide drills)	250	800	2,000
Optimized High-Speed Metal Removal Rate (in^3 per minute)	9.6	30.6	76.4
Machining Cost (per 1,000 holes at $100/hr.)	$253	$78	$32

[†]High-speed machining material optimization testing and analysis performed by TechSolve, Inc.

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[1] Adinamis, G., et al. (2019). High Speed Machining of Brass Rod Alloys. *Modern Machinery Science Journal*, November 2019, 3277-3284. doi: 10.17973/MMSJ.2019_11_2019082

For high-precision parts, brass yields lower costs per part in high-speed, high-volume production with greater machine tool utilization. New machine tools with faster, more powerful spindles can machine brass at those high speeds, enabling shorter cycle times, expanded production capacity and quicker payback periods for capital upgrades.

Brass also offers another profitability edge over other metals, one with an environmental advantage: its significantly higher residual value and recycling efficiency. By comparison, steel and aluminum swarf holds only a fraction of its raw material value and can require additional processing to regain usefulness. Conversely, most post-processing brass scrap holds 75% to 90% of its original value – and brass rod stock is made almost entirely from recycled material.

Conclusion

Manufacturers who want to maximize their ability to respond to changing market conditions as well as to capitalize on new job opportunities need the future-oriented power and performance of modern machine tools to compete for challenging work and accommodate the changing landscape of their workforce. Although these investments in new technology require careful consideration to assure that shops choose the optimal equipment for their workflows, focusing at least some of their attention on brass parts will enable them to take full advantage of their acquisitions.

About the Copper Development Association

Copper Development Association Inc. (CDA) is a U.S-based, not-for-profit trade association of the North American copper industry, influencing the use of copper and copper alloys through research, development and education, as well as technical and end-user support. CDA is committed to promoting the proper use of copper materials in sustainable, efficient applications for business, industry and the home.

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