Broaching in the 21st Century

All Dressed Up with Places to Go

Jack McGuinn, Senior Editor

Back around 2005-2010, the most exciting things that were happening in broaching had little to do with broaching. What was happening — and continues to evolve today — was the emergence of on-the-edge CNC, software and servo drive technology. Together, they practically transformed a metalworking process as old as water into a viable, alternative consideration for producing high-volume part runs. Add to that enhanced tool coatings capabilities (which also just keep getting better) and broaching found itself enjoying a bit of a relevance Renaissance.

But what about now — in 2018? Ten years is an eternity in today's manufacturing operations, with new technology breakthroughs occurring seemingly faster than one can keep up with. Is broaching still in the equation in a meaningful way?

Indeed it is — and then some.

"Yes, broaching remains one of the fastest methods of cutting production parts," says Leon Agan, project engineer/estimator for American Broach & Machine, Inc. "High accuracy remains consistent as long as tools are properly maintained."

Michael Slovak, sales manager/machine tools division for Nachi America Inc., adds additional evidence.

"CNC, servo, and software technology continue to improve and provide additional impact on power savings, high efficiencies, and high-precision mechanical systems. Nachi's primary developments include: Hard broaching to minimize distortion after heat treat. Also, Nachi green and hard skiving, including lathing, drilling and taping, with (6) station automatic tool changer — is a multi-process alternative to broaching on lower part volume requirements. (And), the smaller GMS200 is currently moving into the introduction process."

Given the above, broaching certainly remains a part of gear manufacturing. But, even with the mentioned bells-and-whistles add-ons, can broaching crack manufacturing's 21st century lineup of Smart Manufacturing, IoT, and Industry 4.1?

"Customers now almost always ask for a communication link in the broaching machine control system, which they can utilize

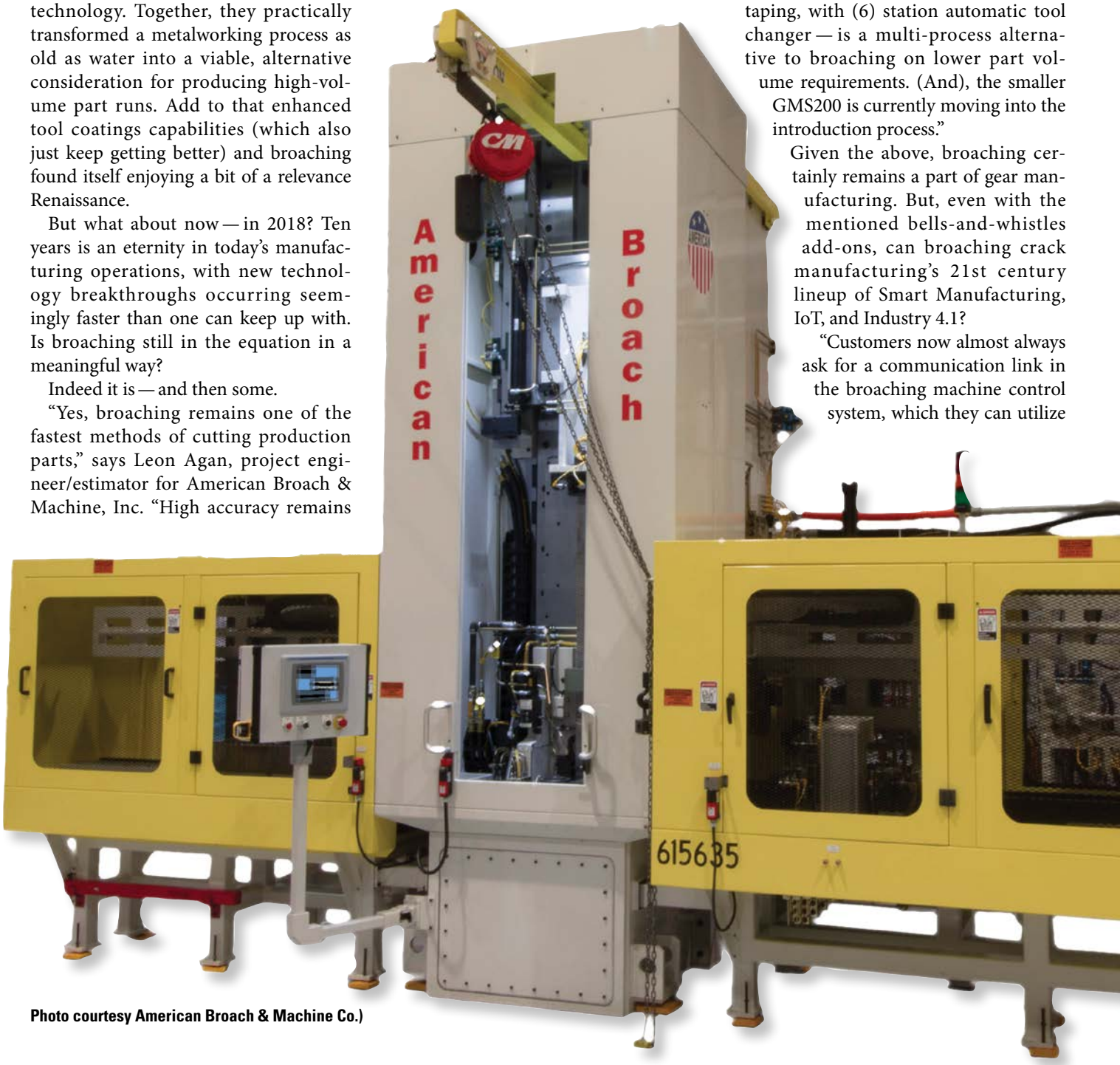

Photo courtesy American Broach & Machine Co.)

in whichever factory management system they are using," says Agan. "Most broaching machines use PLC rather than CNC control, and even those are outfitted with a link for plant connection."

Nachi's Slovak points out that "While the new buzz phrases define a specific characteristic, the technology to participate in these areas has been available to machine makers for many years, and broaching is included. Providing critical data over a secure network to key individuals, optimizing production functions, and increasing automation continue to be improved and utilized."

Not to get too far off message, the thought occurs of how protracted steel tariffs on foreign steel might impact broaching's world — especially tooling.

"As with any change in such policy there is always potential for price impact and broaching must be reviewed on an ongoing basis," says Slovak.

As for American Broach's Agan, see above answer — with this added proviso: "The price of broach tools will be affected if tariffs remain on European tool steels. Broaching machines use large volumes of structural steel, so there will probably be a significant impact on their pricing."

With the techy add-ons, have there been any new applications happening for broaching? Generally no, but those add-ons go a long way towards ensuring that broaching maintains its viability and retains its existing place in the gear machinery universe.

"Most applications remain traditional, but the amount of automation required for production cell integration has increased," Agan says. "Customers want to eliminate broaching machine pits and operator stands, and minimize operator involvement. They ask for features such as onboard measurement of parts. Also, we have come up with several designs to make changeover faster and easier."

Slovak believes "Broaching with 'techy add-ons' can apply to any market that requires high annual volumes and high capability." Looking forward, he also states that "Electric vehicle components may be the largest emerging new application."

Given the fluids involved in broaching, and the maturity of the broaching process, you would think broaching is a particularly down-and-dirty process. But that's not quite the case if proper steps

(Photo courtesy of Nachi America, Inc.)

are taken to alleviate the situation.

American Broach's Agan explains that "Normally, cutting fluid is splashing around freely inside a broaching machine. The process requires a flood of coolant, rather than a high-pressure blast. The current guarding designs do a good job of containing the cutting oil (normally water-soluble), and air blow-off stations can be added to reduce coolant carry-off. Dry broaching methods are being developed, but for now, most customers are still using gallons of cutting oil.

"The typical oil or oil soluble cuttings fluids may not be known as producing a 'clean process,' says Slovak, "(but) steps can be taken to minimize or stop the escape of cutting fluids outside of the machine being utilized. MQL (minimum-quantity lubrication), where available, is contributing to a much cleaner and more cost-effective process."

Back in 2010, what might be considered "old-school" hydraulic machines ruled regarding large-component applications. In 2018? Still very much in the game in a big way.

"Hydraulic machines will always have a role — especially high tonnage long stroke machines," Agan affirms. "They have a fairly simple design and are very reliable. About half of the customer base considers

an electro-mechanical machine for small-to-mid-range applications." He further explains that "Electro-mechanical usually wins when floor space is an issue, or when a plant needs to minimize the amount of hydraulic oil in use."

"Old-school" hydraulic machines still rule in any application where part specification allowances and CapEx budgets drive such a decision," says Slovak.

Is new machinery still a relevant part of the broaching industry? Or re-engineering/retrofitting existing machines? "New machines are about two-thirds of our machine sales," says Agan. "Most of the time, we can offer our customer a completely rebuilt used machine as a lower-cost alternative. The frames of old machines last a long time, and with careful restoration of sliding surfaces and the addition of modern controls, we can confidently offer the same warranty that we provide with a new model."

"New machinery is relevant based on highly engineered part specifications and quality capability requirements," Slovak says. "Complete rebuilding of an existing machine can be an attractive, economical solution, (but) when the right frame is not available a new machine is recommended."

From the technological mindset of what have you done for me lately, have there been additional software, CNC, servo upgrades in this decade that have further enhanced broaching capabilities in a significant way?

Slovak cites "Continued improvements in human machine interface capability and programming can allow for improved and more efficient setting of processing requirements. The CNC, servo-operated machines continue to allow development in processing speeds, achieving faster machine cycle times."

As for Agan, he presents a somewhat less sanguine view. "Broaching does not benefit a whole lot from CNC advancements in the number of controlled axes, the ability to coordinate axes, or more sophisticated part programming software. We have a straight line application for the most part." But also offers that "Many control systems have become more open to industry standards and interoperable with motors from other brands."

As mentioned, broaching is intended for high-volume production runs. So what goes into identifying the high-volume break-even point that determines whether broaching is more cost-effective than other cutting technologies?

"Ten thousand pieces is still considered to be very low volume in the broaching industry," says Agan. "Considerations are: new vs. used machinery; initial tooling cost; the total length of cut expected between sharpening; the number of runs-per-tool; and the cost of sharpening. American Broach can provide specific information when quoting a job to help a potential customer decide if broaching offers the best value."

Add to that, according to Slovak: "Reviewing the part volume against initial CapEx costs; amortizing schedule; ongoing perishable tooling costs; regularly planned machine maintenance

costs; ongoing utility costs — as compared to the alternative cutting technologies using the same factors."

So broaching not only has a long history; it would also appear to have a strong future. The new wine in old bottles metaphor seems to apply here in a meaningful way — or is it *old* wine in *new* bottles? — (never can get that one straight). According to American Broach's Agan, "There has been a great increase in the number of customers seeking a hard broaching (a recent vintage) solution. We have been working with several to develop a process which is most effective for them."

Nachi America's Slovak's outlook is positive as well, but points out that there is much due diligence involved to keep it that way and to maintain market share.

"The markets are requiring broach builders to supply finishing processes with high speed, on a wide variety of parts, and lower volume production runs. We have moved toward market demand with CNC broach machines (mass production), compact hard broach machines, small or large helical broaching machines, and skiving (wide part variety, lower production) machines. We are also able to offer integrated solutions with robotic (Nachi Robotic Systems) load/unload automation for all machine types. Our broaching machines and skiving machines are solutions for covering customer process trends."

Photo courtesy American Broach & Machine Co.

Types of Broaching

(*Courtesy American Broach & Machine*)

- **Pot (external spline or profile).** A part is pushed up through a circular array of surface broaches, resulting in a gear or similar form on the outside circumference; high throughput with good surface finish.
- **Horizontal.** A broach tool is pulled horizontally through a part placed in a fixture or on a work horn. Commonly used for cutting keyways and windows, but can also be used for internal splines with looser tolerances.
- **Vertical Table Up Broach**. The part is set in a fixture on a ram which carries it over and past a stationary broach tool. The advantage is a convenient load height for the operator, as no pit or operator platform is required.
- **Vertical Pull-Down Broach.** The part is placed in a fixture, and a broach tool is pulled downward through it to produce an internal form. These machines are very rigid and can produce cuts with tight tolerances and very good surface finish. The disadvantage is that the work table is very high relative to the floor.
- **Vertical Surface Broach**. The part is clamped in a fixture, and a set of flat broach tools on the ram slide move past and cut into the external surface. This process can produce flat surfaces or complex forms, such as spline racks or turbine hub "fir tree" slots.
- **Twin-Cylinder Pull-Down Broach.** This is a form of pull down broach which has a pair of cylinders (or linear actuators) mounted to the work table and stroking downward into the base of the machine. The ends of the cylinder rods are bridged, so that they can carry the pull head. This system keeps the pull force in line with the broaching axis, which eliminates cantilever effect inherent in other systems. The pull lug is also guided on ground posts, maintaining a high degree of broaching accuracy.
- **Table Top Broach.** This is another form of pull-down broach with a small footprint and compact design. Instead of a ram slide, a pair of ball screws on each side of the broaching axis moves the pull lug. American Broach & Machine Company builds this "TT" model, which has many of the same high end features as larger machines.

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