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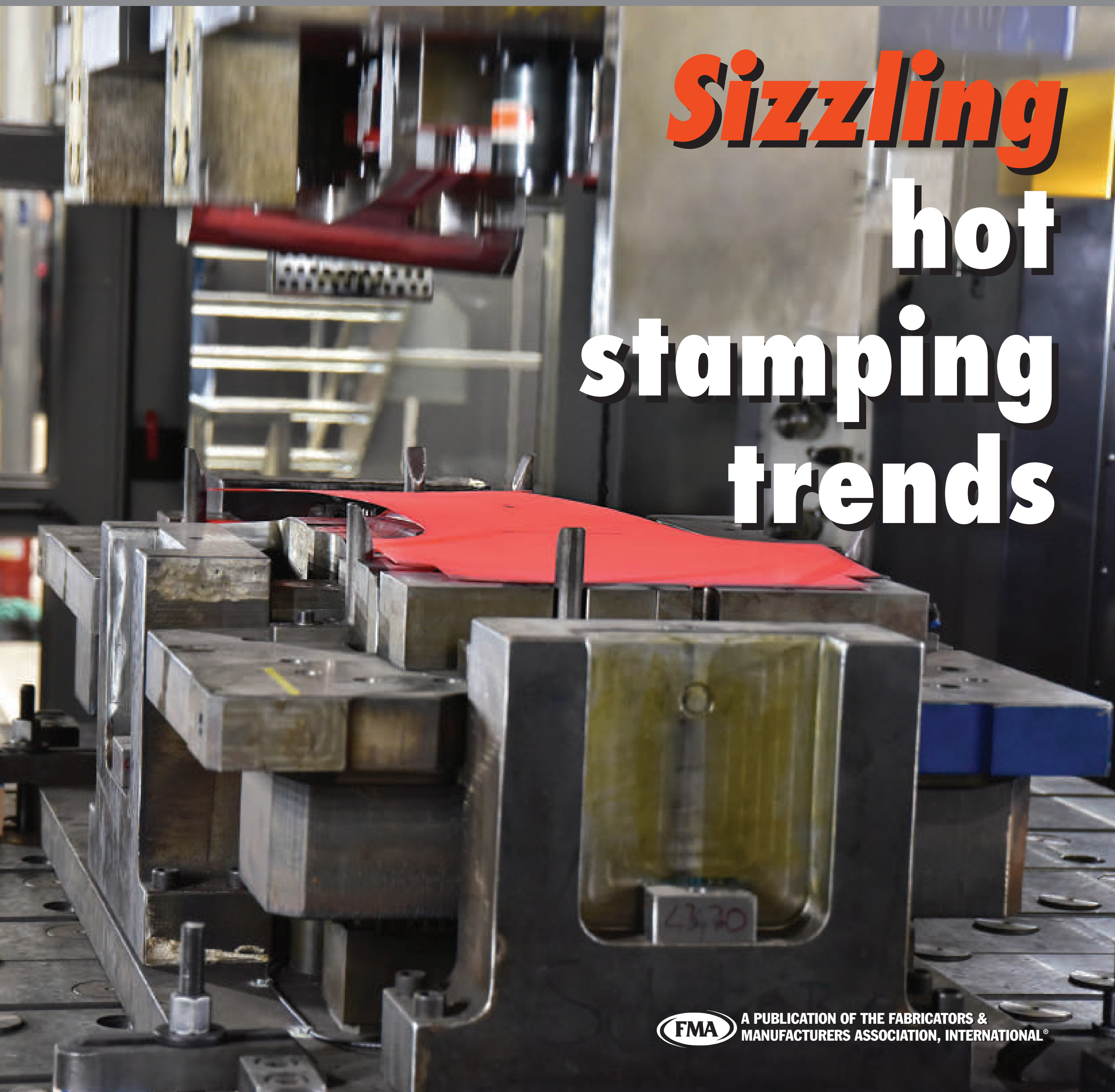

Sizzling hot stamping trends

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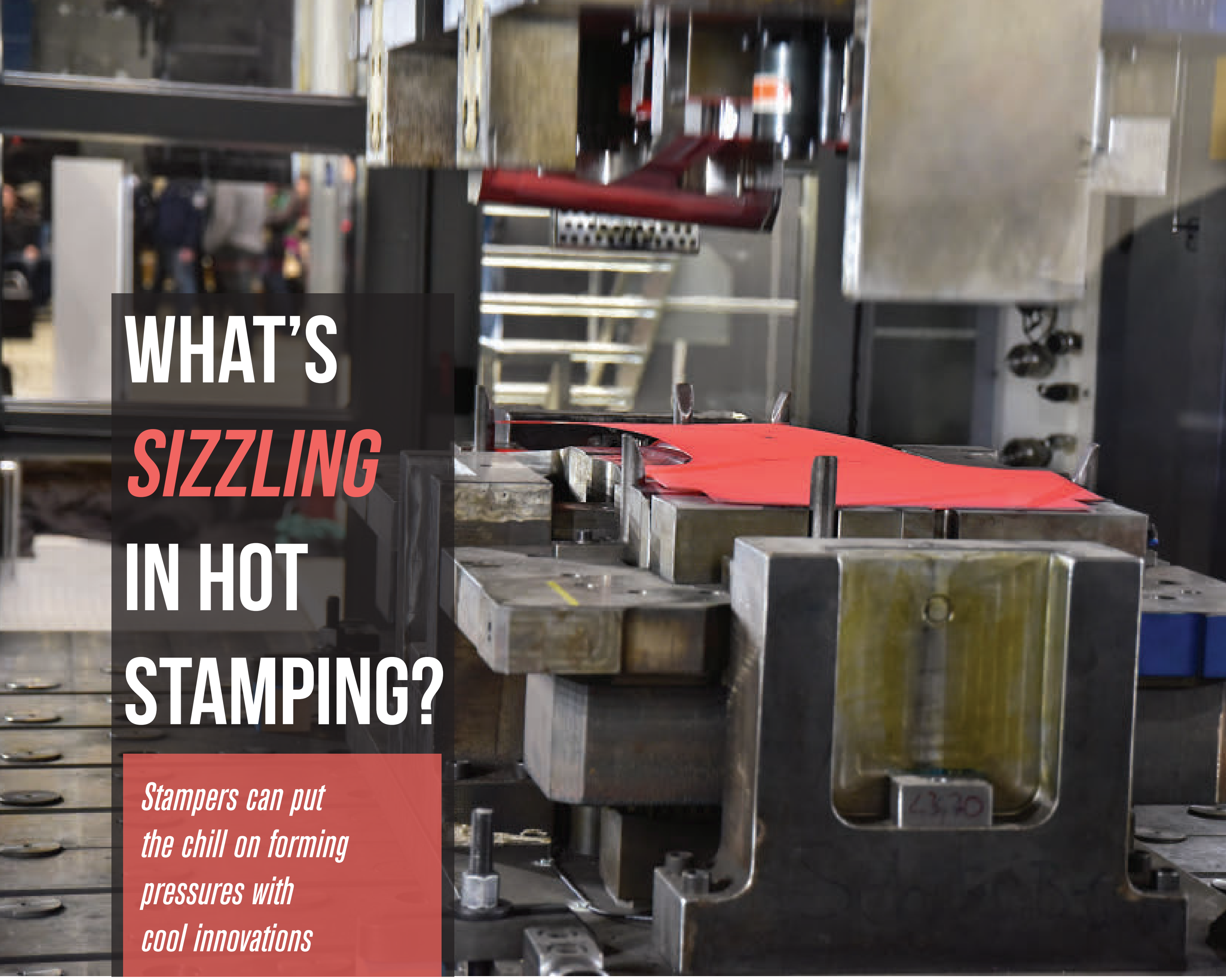


WHAT'S *SIZZLING* IN HOT STAMPING?

Stampers can put the chill on forming pressures with cool innovations

Hot stamping's innovations may help ease forming pressures for light yet strong automotive components. Photo courtesy of Schuler Group, Göppingen, Germany.

By Kate Bachman

The popularity of high-strength parts continues to drive increased demand for hot stamping presses, according to Josh Dixon, director of sales and marketing for Beckwood, Fenton, Mo.

Stamping manufacturers using hot stamping technology (see **lead image**) to reduce vehicle weight, fuel consumption, and environmental impact fall into two categories, said Schuler Group Sales Manager Hot Forming Jens Aspacher. "First, there are the newcomers that are forced to step into this technology by their OEM customers. Second, there are manufacturers already hot stamping that face a huge price pressure on the parts and therefore need ways to increase productivity and reduce their own manufacturing costs."

Aspacher proposes that, although its capital costs remain high compared to conventional stamping, hot stamping is an economical resolution to those pressures, even if it requires longer cycle times and specialized equipment, because it enables stampers to form light, strong, complex, and dimensionally stable parts in one step.

"To ease further adoption of hot stamping, we [OEMs] have to cut cycle times and reduce energy consumption even more," Aspacher said.

Fagor Arrasate Managing Director of Press Hardening Systems Aitor Ormaetxea also thinks cost pressures are steering the technology's direction, and believes that press OEMs must lower its costs. "Present challenges for the manufacturing industry are reducing hot stamping's costs, because it still is considered an expensive process," he said. Another is ensuring part quality stability, he added.

AP&T is collaborating with a multi-organization group whose aim is to develop low-cost forming of lightweight structures for transportation industries, according to AP&T's Director of Technology Development Dr. Christian Koroschetz.

Hot Stamping Innovations, Changes

Press OEMs have expanded the technology to help meet stampers' challenges:

- Hot stamping used to form materials other than boron steel, such as aluminum and magnesium
- Improvements to provide better control over the hardening process, higher output, and greater efficiency
- Option of using either a servo-mechanical press that has been modified for hot forming or a hydraulic press
- Secondary processing performed in-die

Aluminum, Nonferritic Metals

According to both AP&T and Fagor Arrasate spokespersons, one new development is hot stamping nonferritic metals, particularly high-strength aluminum alloys. Considering that aluminum is considered to be a soft metal, why is it necessary to hot-form it?

AP&T's Koroschetz explained. "There are different kinds of aluminum alloys available—low-strength alloys (2xxx) and high-strength alloys (6xxx and 7xxx). The soft, or low-strength, ones show very good formability for complex-shaped components. However, very often, structural components have geometries that are difficult to stamp. This means that to form components that are both strong to meet safety requirements and lightweight, you need to use high-strength materials. So hot forming is needed to form high-strength aluminum for the same reasons it is used to form high-strength steels.

"To make these materials formable, you heat them up to so-called solutionizing temperatures, form them, and quench them. After undergoing an artificial aging process, they will return to their very hard state again."

AP&T has developed a production line to hot-stamp aluminum, incorporating a new method developed and patented by Impression Technologies (ITL) using heat treatment, forming, and in-die quenching (HFQ®). The line development is part of a multiorganization collaboration backed by the U.K. government's Advanced Manufacturing Supply Chain Initiative. The HFQ method was developed at the Universities of Imperial College London and Birmingham and is now being commercialized in LoCoLite, an EU FP7 NMP project that aims to enable the use of a patented materials processing technology for low-cost forming of lightweight structures for transportation industries (see **Figure 1**). CIPCO, a subsidiary of ITL and PAB Coventry, is trialing the process. CIPCO will use the new production line to manufacture lightweight parts for several British auto manufacturers, as well as for continued R&D on the HFQ process. The LoCoLite project has produced its first prototypes using the new method, and the first production line is scheduled for installation early this year.

The new process allows high-strength aluminum alloys to be formed into complex geometries through increased formability, Koroschetz said. As a result, sharper bend radii can be produced. In addition, it nearly eliminates springback. "These are significant advantages compared to traditional stamping processes. These qualities are of major interest for the automotive industry."

The hot stamping process, currently applied to boron steel, has to be modified to form aluminum, Koroschetz added.

The process route itself is the same: Heat up the material, form it, and quench it, he said. "However, there are several differences. Hot forming aluminum requires an additional aging process for it to reach the final mechanical properties needed. Material handling during this process is completely different. New heating technologies are required. Lubrication is required. New tooling concepts must be used, including tool material and coatings."

Even the presses themselves must be operated differently, Koroschetz said. Faster presses with lower press tonnage are needed. "Also, the postprocessing can be different. Most likely, the final parts produced will not require laser trimming."

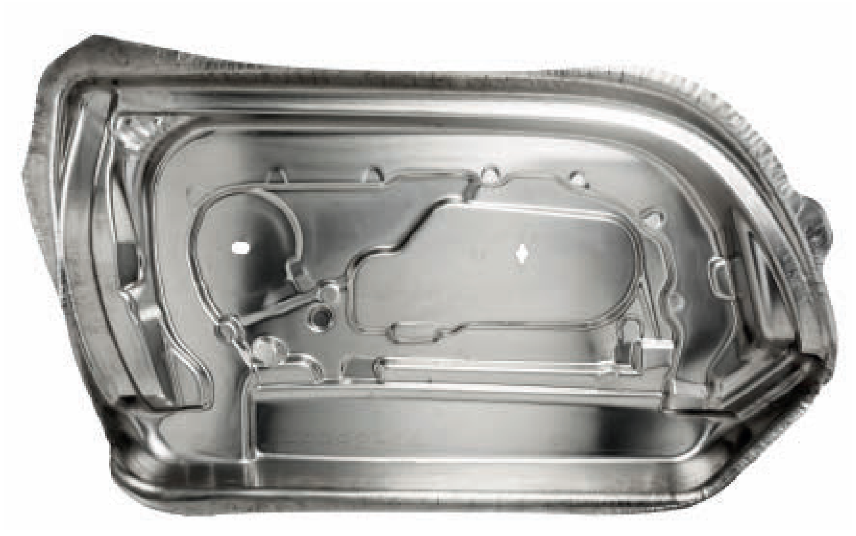


Figure 1

An aluminum part was hot-formed using AP&T's HFQ® technology as part of a European-funded research project called LoCoLite. Photo courtesy of AP&T, Ulricehamn, Sweden.

IMPROVED CONTROL

Hot stamping is critically dependent on time and temperature throughout the various stages of the process. Each stage requires that a different set of time and temperature variables be controlled in an accurate and repeatable manner, Dixon said. "The three most critical stages are austenitization, transfer, and the martensitic transition. If you do the simple math with the number of variables times three, the need for tight process control is clear. Creativity comes into play once you add in the challenge to improve throughput efficiencies."

To shorten the total hot stamping process, stampers require extremely fast press speeds and high-speed transfer systems to minimize air cooling of the part when it is transferred from the heat source to the press, Dixon said. Even the die design can enhance the effort. "Common boron steels require a minimum cooling rate of 27 to 30 degrees C per second—the faster, the better. Optimized dies can cool at rates of 100 degrees C per sec., drastically reducing the cycle time," Dixon said.

Because austenitic parts can cool rapidly at rates from 12 to 20 degrees C per sec. when exposed to plant air, faster transfer and shorter press cycles are important, Dixon continued. Minimizing heat loss during transfer time and closing the press also minimize the temperature at which the part needs to be heated above the martensitic starting temperature to compensate for the loss. "This improves not just the efficiency of the transfer and press stages, but also improves the efficiency of the heating stage. So, efforts have focused on developing flexible and fast transfer systems that can be adjacent to the press to minimize transfer distance and improve press ram speeds for rapid closure."

Schuler introduced its pressure-controlled hardening technology, called PCH®flex. It is designed to produce hot-stamped parts with higher output and better quality and reliability more economically than before, Aspacher said.

The technology facilitates increased productivity and part quality by controlling pressure during hardening. "The flexible bed cushion applies press force uniformly over the entire part or several parts. This results in faster cooling and a reliable, optimized metallurgical transformation process," Aspacher said. The cooling time is half that of conventional methods, he added.

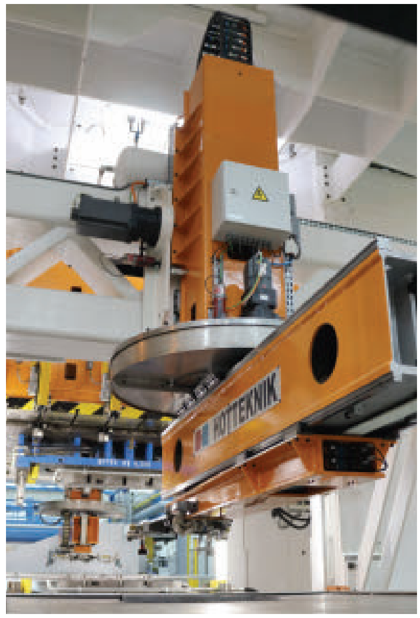


Figure 2

Stampers can increase the overall equipment effectiveness (OEE) in their hot stamping processes by using automated and optimized quick die change methods, as does Tower Automotive at its Elkton, Mich., plant. The Tier 1 supplier is prepared for die changes in its hot stamping process in less than 15 minutes. Photo courtesy of Fagor Arrasate USA, Willowbrook, Ill., and Tower International, Livonia, Mich.

"With four parts per stroke in a four-out mode, stampers can produce up to 4 million parts per year on one line," Aspacher said.

How does the technology control pressure during hardening? After being heated in a furnace to a temperature of 930 degrees C, the blanks then have to be fed into the press as quickly as possible to prevent rapid air cooling. There is a time window of just 10 to 12 seconds, Aspacher relayed. The press remains closed for a few additional seconds after the forming process. During this time, the parts are cooled and hardened. "A key factor in determining high quality and short cycle times is the fast heat transfer from hot part to cooling water. The weakest link in this chain sets the speed," he said.

The determinants of the part's cooling period include the transferred energy, which depends heavily on the blank thickness, as well as the heat transfer between blank and die, Aspacher continued. "Additional factors are the die's thermal conductivity and energy dissipation, such as the number of cooling channels, the temperature of the cooling medium, and the flow in the cooling channels. The general rule is, the higher the contact pressure, the faster the heat transfer and the shorter the cooling time—and the better the performance.

"Normally, this contact pressure is produced by spring assemblies, nitrogen gas springs, or hydraulic cylinders in the die. By greatly increasing the contact pressure using PCHflex cushions and dies, optimizing the cooling channels, and selecting the die steel according to the part, we succeeded in further accelerating the heat transfer process and thus drastically reducing cycle times," Aspacher said.

The technology is engineered to cushion die and material fluctuations because it compensates for varying tolerances and sheet thicknesses. "This reduces scrap and downtime that would otherwise occur by having to rework dies, for instance," Aspacher said.

No additional modifications are needed to the dies to use the technology. Existing conventional press-hardening dies can be used on these lines, and dies designed for the technology can be used on conventional lines.

SERVO PRESSES HOT STAMP

One new strategy manufacturers can use to reduce the cost of hot stamping is to use servo press technology to reduce energy consumption and, therefore, costs and carbon emissions, Fagor Arrasate USA's Ormaetxea said (see "Servomechanical press makes foray into hot stamping," Sept./Oct. 2015

STAMPING Journal). The press OEM is currently finalizing the installation of a 15-kilonewton (kN) servo press for hot-forming parts in continuous production.

"Hydraulic presses have some energy efficiency vulnerabilities," Ormaetxea said. "In a hydraulic press, the pump motor runs most of the time whether or not force is required. This continuously running motor requires energy—up to 30 percent of the installed power in a conventional configuration. Conversely, in a servomechanical press, the motor runs and consumes energy only when the slide is moving, so it consumes 30 percent less than a hydraulic press."

IN-DIE SECONDARY PROCESSING

Die technology is about to undergo a great advance in the following years, according to Ormaetxea. The company has been working in a partnership with Batz, S. Coop, with ongoing developments to eliminate or reduce part post-processing such as cutting, piercing, and punching. "These secondary processes currently are executed by laser cutting, but some of them will be made simultaneously in the hot-forming die."

REDUCED ENERGY CONSUMPTION

Hot stamping technology is evolving to reduce the energy required to perform it, press OEMs said.

Schuler's efficient hydraulic forming (EHF®) approach helps cut down the energy consumption of production equipment by as much as 60 percent compared to conventional hydraulic presses, Aspacher said. "The technology's standby function ensures that the main drives are automatically switched off when not required. We also developed a patented startup system that can bypass the usual startup characteristics of drives and thus utilize even the shortest breaks without any time loss. This not only reduces energy consumption, but also noise emissions," he said.

The speed control for power take-offs also reduces energy consumption, Aspacher continued. Normally the press operates at a constant speed. The result is frequent idling and unnecessary energy consumption. Schuler's EHF uses an intelligent, speed-controlled drive which supplies the auxiliary functions with energy only when actually needed. This effectively minimizes idling losses. The auxiliary functions are powered irregularly, depending on the machine's current status.

The technology also has lower cooling needs, he continued. "The control valves in the main circuit have been eliminated and their function has been taken over by servo pumps. Taking into account the applicable safety regulations, Schuler has reduced the number of components in the main circuits to a minimum."

The potential energy of the slide during rapid downstroke and the energy stored in the oil compression is fed back into the production process by using the discharged oil to drive units, which generate power with electric motors, according to Aspacher.

PRESS OEMS AS SYSTEMS SUPPLIERS

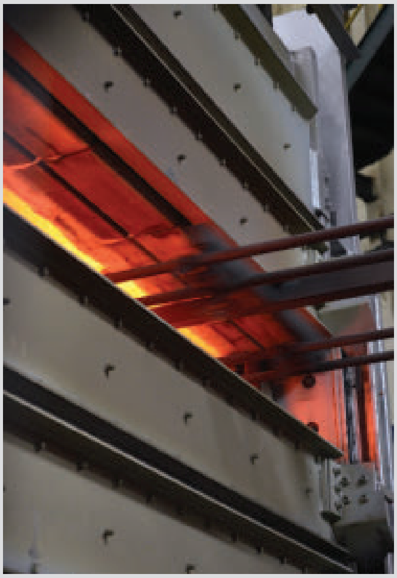
Another hot forming trend is for press manufacturers to act as systems suppliers, the press OEMs said. It has become standard practice for them to supply not only the presses, but also the heating equipment, automation equipment, and even the dies.

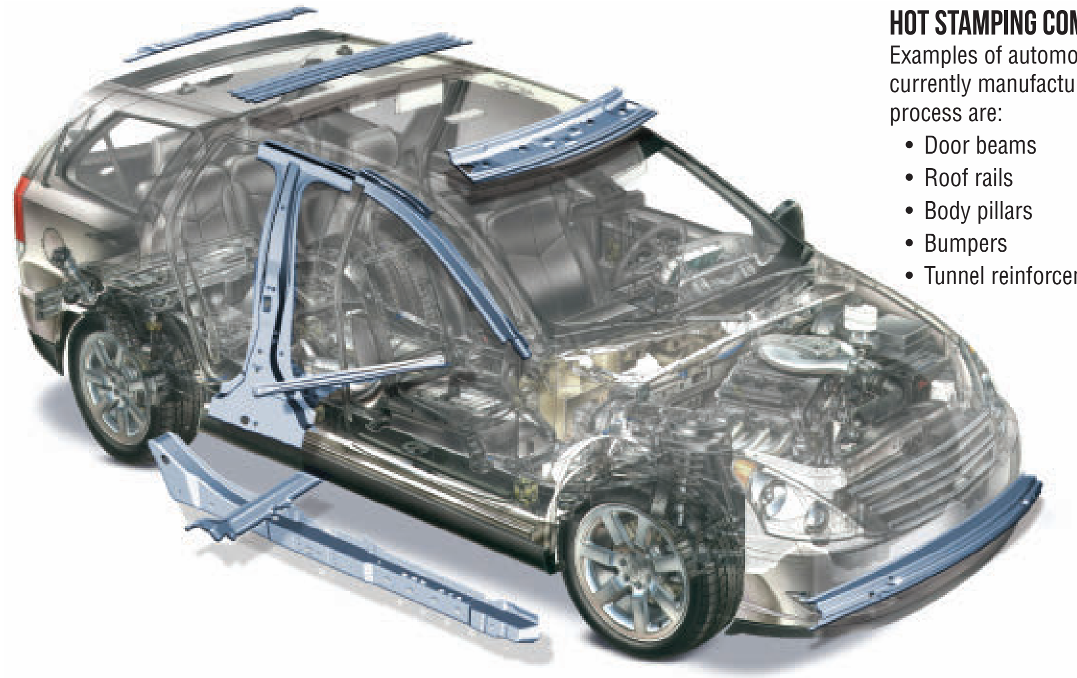
"Hot stamping is not just another application of metal forming; it is a complete heat treatment process of the material with a change of the microstructure. For most of the press shops, this is new and a big challenge," Aspacher said. Press manufacturers need to make sure everything is up and running. This is important especially for newcomers, he added.

Ormaetxea said press manufacturers supplying hot stamping systems can help stampers take a whole-systems approach. To reduce hot stamping's costs, Ormaetxea recommends that stampers apply some of the same systems and strategies they use to reduce costs in conventional stamping to hot stamping as well. "Increase hot forming line productivity by always working with four blanks in one stroke. If necessary, use bigger presses. Also, reduce cycle time by using high-speed transfer systems," he said.

CASE EXAMPLE:
STAMPING MANUFACTURER USING HOT STAMPING

Tier 1 automotive supplier Martinrea has two facilities specializing in hot stamping, according to the company's website. "The hot stamping process enables the use of high-strength steels for products particularly critical in occupant safety, such as pillars, roof rails, door beams, and bumpers. The ultrahigh-strength steel (UHSS) used in the hot stamping process is of great benefit to an industry focused on weight reduction and under constant pressure for increased crashworthiness performance. The high strength-to-weight ratio of the UHSS used in hot stamping enables better crashworthiness performance ratings while often decreasing or maintaining weight neutrality."





HOT STAMPING COMPONENTS

Examples of automotive components currently manufactured in a hot stamping process are:

- Door beams
- Roof rails
- Body pillars
- Bumpers
- Tunnel reinforcements

Ormaetxea added that stampers can increase their overall equipment effectiveness (OEE) by using automated and optimized quick die change methods. "For example, our latest installation in Tower Automotive is prepared for die changes in less than 15 minutes," (see **Figure 2**).

Dixon said that Beckwood Press' focus has been to incorporate more of the process into its technology offering. "We're adding faster methods of part transfer with servo transfer systems to help our customers achieve better process and throughput results," he said.

He is also looking at alternative heating processes. "Roller furnaces were once the most common process for heating." Currently, the company equips its systems with induction heating. "Now we are actively working with customers on conduction heating systems that have the potential to minimize a lot of the inconsistent variables associated with hot stamping. We see this alternative heating system as having high potential to improve the hot stamping process," Dixon said.

FUTURE OF HOT STAMPING?

The press OEMs predict that hot forming technology will continue expanding as lightweighting pressures heighten. In the future, the percentage of structural autobody parts that will be hot stamped could rise to between 30 and 40 percent, press OEMs predict.

"Because of the growing global requirements for improved passenger protection and the need to reduce CO_2 emissions, demand is expected to grow in the coming years," Aspacher said, pointing to Volkswagen's increasing use of hot-stamped parts as evidence that the technology is becoming more prevalent. "Every new car that comes on the market has more hot-stamped parts than the model before. With its latest Golf model, Volkswagen has reversed the spiral of increasing weight for the first time." He added that Schuler recently received an order for four production lines from another automotive producer.

"We're quite optimistic that we will continue along this path."

Ormaetxea predicts that many innovations are imminent, including more end-of-line and front-of-line developments. "The front-of-line will become more flexible so that different types of parts can be combined in the same production batch. At the end-of-line, integrated part racking, rather than manual systems used currently, will become standard."

He also forecasts the increased use of other metals other than steel. "At the present time, different processes are being evaluated for aluminum warm forming; in the following year, it is going to be standardized and, in many cases, will be a real alternative to steel parts."

Koroschetz said he is excited about the future of car body structures. "In the future we will either see a strong multimaterial mix that will include carbon fiber composites and magnesium, or a singular focus on one specific material like aluminum. Examples of this are the Ford F-150 and Jaguar Land Rover. Therefore, our goal is to support customers on all levels."

Editor Kate Bachman can be reached at kateb@thefabricator.com.

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