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# Metal Forming

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**Straightening Higher-  
Strength Materials**

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# Straightening AHSS— The Science Behind the Solutions

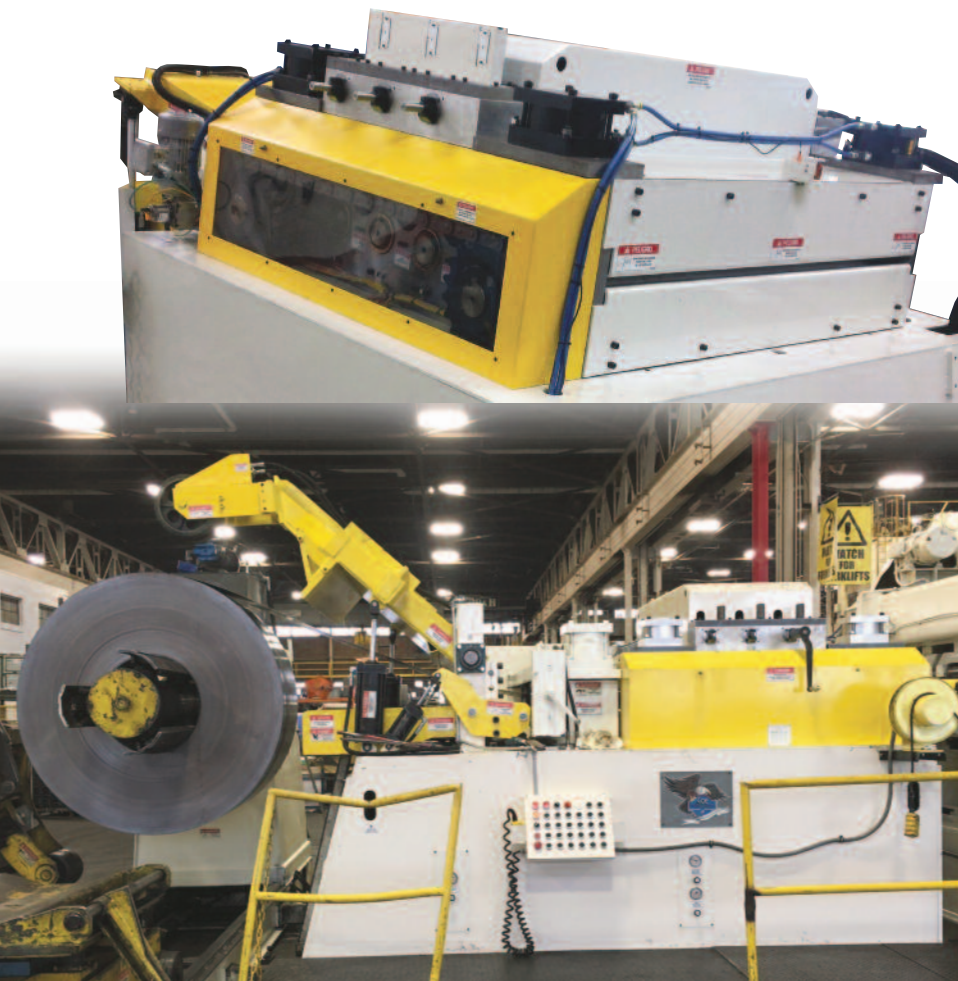
Stamping advanced high-strength steels can double the force and torque required of feed-line straighteners designed to feed mild steels. Often, custom straightener solutions are required to fit the application. New software utilities can provide proof of concept before investing in new equipment.

BY BRAD F. KUVIN, EDITOR

**M**etalformers must be confident that the machines they're buying will stand up to the materials they're tasked with stamping today, and in the future. That's the message coming loud and clear from suppliers of pressroom equipment in light of the onslaught of challenging metal alloys making their way into metalforming plants. Of primary concern are the numerous advanced high-strength steels (AHSS) that for several years have been mainstays in Tier One and OEM stamping facilities. Now these materials are making their way into many Tier Two and Tier Three stamping plants.

Compared to earlier times, when metalformers dealt primarily with steels in the yield-strength range peaking at around 50,000 psi, working with steels in the 100,000-psi or greater range requires an entirely new and unique set of equipment. And, the first step in the AHSS-forming process is perhaps the most challenging: straightening. To gain an understanding of the severity of this specific challenge, and for an update on how technology is evolving to support the stamping community, we spoke with representatives from Coe Press Equipment Corp., Sterling Heights, MI.

"The most challenging step in the process of delivering AHSS sheet to the press is straightening," says Coe



*In many cases, just replacing the top half of the straightener is all that's needed to equip an existing coil-feed line to reliably feed AHSS. This includes, as illustrated here, a new head with the structural design and component content able to deliver the force needed for the application. Changing out components in the straightener involves, typically, use of smaller-diameter straightening rolls than those typically specified for shaping mild steels, and use of tighter center distances. The gearing also typically is upgraded.*

research and development manager Bruce Grant. “We see this as the biggest need in the industry today, and the biggest shortcoming of the equipment that’s been manufactured and in use by stampers during the last 30 years or so. To overcome these shortcomings, we’ve identified where the design enhancements are needed to ensure that the equipment will perform as needed, with the reliability and dependability stampers require. That starts with the development of software utilities that allow stampers to evaluate the new equipment from a design and performance standpoint, to give them confidence in the equipment as they take on these challenging materials.”

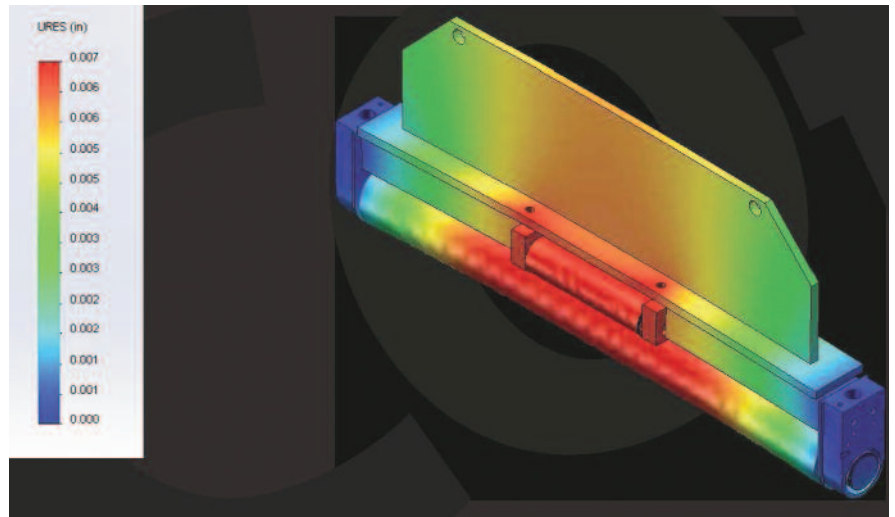
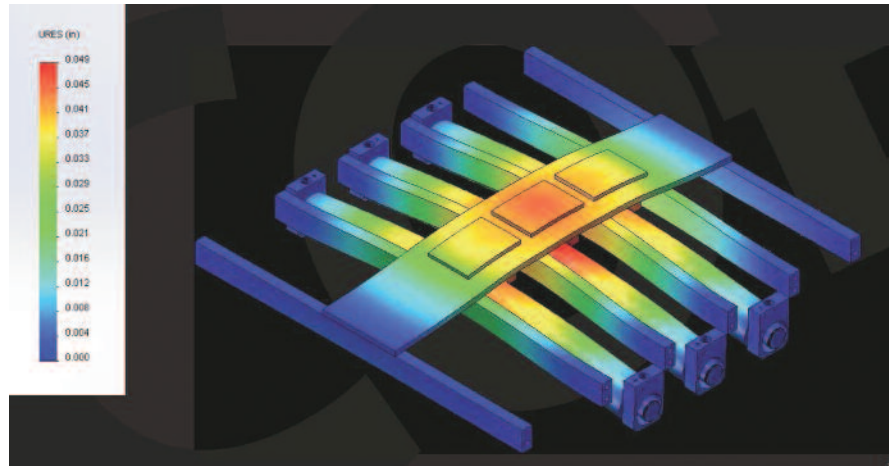
### Force, Torque and Roll Deflection

It all starts with calculating the forces needed to bend and straighten these higher-strength materials as they feed from coil through the feed line to the press. The software utilities Grant describes can determine these forces based on material properties and coil width, with the goal of removing coil set and cross bow.

“Then we must calculate the torque required to drive the straightening rolls,” he says, “in order to impart the needed forces on the material. And, finally, we can use finite-element analysis (FEA) to verify that the machine design and gear train will withstand the forces generated.”

What’s the impact of increasing material yield strength from, for example, 50 ksi to 90 ksi? According to Grant, such an increase results in an 81-percent increase in the amount of force required, along with a 67-percent increase in required horsepower and 63-percent increase in pinch-roll gear torque.

“Roll deflection in these high-force applications is a primary concern,” adds Coe engineering manager Jim Ward. “We see in many cases that the older equipment used by stampers generally lacks the force delivery to the work rolls needed to adequately bend AHSS material. Or, while the straightener may be able to apply the force needed, it won’t have sufficient roll support. As a result,



Software utilities can simulate roll deflection under load. A conventional straightener (left) exhibits 0.049-in. deflection with 60,000 lb. of force applied, while the rolls in a straightener designed for AHSS deflect only 0.007 in.

the rolls deflect under load and induce edge wave into the sheet.

“Another issue we see,” Ward continues, “is with gear-train reliability. We’ve seen gear teeth knocked off and gears wearing prematurely, after having to straighten AHSS materials. And, feeding AHSS can burn up motors and snap journal ends.”

### The Retrofit Options

This seemingly dire situation, however, is coming to an end, as suppliers get a handle on how to meet the challenges posed by forming AHSS sheet. They’re developing the science needed to overcome the challenges posed, as the “norm” goes from stamping 50-ksi steel to dealing with steels with yield strengths of 100 ksi or more. Suppliers

are using FEA and other tools to develop new solutions, which Ward says typically fall into one of two categories.

“We see stampers looking either at total coil-line replacement in order to solve reliability issues when stamping AHSS, or just retrofitting the straightener of an existing line,” he says. Total coil-line replacement, including equipment for coil containment and threading, requires an entirely different business case for justification than does a straightener retrofit.

“There’s a lot more stored energy in AHSS coils,” stresses Ward. “In addition to the straightener, stampers must consider the capabilities of the holddowns and holdups, as well as the threading-drive systems, end-wheel systems and the braking system.”

# Straightening AHSS

However, in many cases, say Ward and Grant, just replacing the top half of the straightener suffices, to equip an existing coil-feed line to reliably feed AHSS. This includes a new head with the structural design and component content able to deliver the force needed for the application. Using the aforementioned software utilities, the stamper can be assured that the retrofitted straightener will be able to sufficiently backbend the material and apply the required roll-depth penetration. And, there's assurance that the machine will have the required rigidity and structural integrity.

For example, Ward describes use of such a utility to prove-out the capabilities of a straightener for flattening ¼-in. 90-ksi-yield steel fed from 48-in.-wide coils. The software utility predicted for the customer that the application required roll force of 38,000 lb. (rated force of the machine was 60,000 lb.), pinch-roll gear torque of 31,400 in.-lb. (compared to a rated torque of 45,100 in.-lb.) and straightener-roll torque of 21,200 in.-lb. (compared to a rated torque of 31,500 in.-lb.)

## Smaller Rolls, Tighter Spacing

Changing out components in the straightener often involves use of smaller-diameter straightening rolls than those typically specified for shaping mild steels, and use of tighter center distances to improve force transfer to the material. The gearing typically is upgraded to handle the increased forces and torque.

"In one recent retrofit project," says Grant, "we upgraded a 1995-vintage straightener for feeding AHSS into a progressive die. The requirement was to feed 100,000-psi material from 60-in.-wide coil. Using our software tools

and FEA, we were able to illustrate for the customer that the new support bridges designed for the straightener would provide sufficient structural support for the new straightening rolls. We also proved out, using simulation software, the new gearing system designed for the application."

"We often see the need to increase roll pressure by two or three times when upgrading from mild steel to AHSS," adds Ward. "This requires upgrades to many straightener components, including the bearings, roll journal, roll supports and the machine structure, including the weldments. Still, we often can cost-effectively meet the needs of the stamper by retrofitting the straightener for one-third or less of the total cost to replace an entire feed line. And, in many cases the stamper can pay for the retrofit from its maintenance budget rather than making a big-ticket purchase from its capital-equipment budget."

So, what should stampers look for, and ask for, when approaching equipment providers for help upgrading their operations to handle AHSS and other high-strength materials?

"Ask for the data," says Grant. "Do your homework, and seek to understand the science behind the technology being proposed. Study the FEA analyses to understand exactly how the machine will respond when it's required to impart the high torque and forces needed to shape high-strength materials. Look, for example, at the roll-displacement vs. stress-analysis data. This will ensure that the machine has been properly designed to handle the stresses. Simply adding mass to the machine oftentimes proves insufficient. The added mass has to be located in the right locations on the

structure to yield the required results."

## Simulation of Deflection Under Load

For example, using the tools that Coe has developed can clearly depict deflection under load of an older machine vs. that of an upgraded machine. "We might see 0.049 in. of deflection under load when trying to run AHSS in an older straightener," says Ward. "A new machine, meanwhile, will have a bridge that deflects only 0.007 in. We can illustrate for the stamper, in simulation, that and other key performance enhancements made possible by upgrading the straightener to handle the increased loading from feeding AHSS. As a rule of thumb, we must keep roll deflection to less than 5 percent of material thickness across the width of the material. Any more than that and the straightener will start to induce edge wave in the material."

Other utilities illustrate for the stamper the required straightener-roll settings for a given material type and coil width, and can specify threading-drive size, holddown force, drag-brake tension requirements and more.

"Tough times require new tools," Grant says, summarizing his thoughts on the new challenges stampers face due to the onslaught of higher-strength materials. "New software tools allow suppliers to simulate for customers how upgraded equipment, designed to handle these new materials, will perform on the shop floor before equipment is purchased. And we can show them how changes in process variables will affect the outcome.

These often are unique machines we're developing," Grant concludes. "There's nothing off-the-shelf." **MF**



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