Excellence in sheet metal starts at the press brake

Five foundational elements that help turn a press brake operator into an engaged expert

By Tim Heston | September 22, 2025 | Article | Bending and Forming

When the press brake department perfects what it does and the pieces fall into place, so does everything else. *Images: AMADA AMERICA*

Bending technology has come a long way in recent years. You have offline programming and simulation, automatic tooling changing (ATC), real-time angle measurement and correction, dynamic crowning, fixed-height punches and dies, common-shut-height die systems (allowing multiple V openings in a single setup), and robotic and cobot bend cells with process simulation and intelligent vision. The list of technological advancement goes on.

In his office at the AMADA Carolina Technical Center in High Point, N.C., Tyler Smith works with this technology nearly every day. But in an adjacent classroom, he does something odd: On the very latest press brake technology, he changes machine parameters to set the backgauge—incorrectly.

As Bending Academy supervisor for AMADA AMERICA, Smith is purposefully setting up a (very accurate) press brake so it's off ever so slightly, so operators can learn to compensate for dimensional bend error during the bend sequence and forming process.

These days, modern equipment has become so good, even novice operators can bend a part correctly the first time, especially if someone else simulated the bend offline and set up the tooling. Fabricators can't ignore the benefits of new technology, but they also want to avoid employing the "pedal pusher" stereotype. That person might produce good parts all day, but they're not engaged. They have few if any ideas for improvement. The apathy builds, and so does staff turnover. That's not a healthy way to grow.

"The Bending Academy is focused on making the operator not only understand the machine but also understand the bending process and the theory behind it," Smith said.

To that end, Smith described five foundational elements that help turn a machine operator into an engaged expert. The list isn't exhaustive, of course. His classes cover everything from tonnage to minimum flange lengths to hemming to incremental (bump) bending. But the list does help illustrate what really matters in the forming department. And as Smith explained, when forming really falls into place, so does everything else.

1. Know How the Bend Occurs

When the punch descends and air-forms a bend, it forms a radius that forces the metal to elongate, as described by the *bend allowance*—the (now longer) distance around the bend radius—and compensated for by the *bend deduction*, where you deduct a bit from a piece's overall dimension. This way, as you form the piece, it elongates to the dimension you need within a specified tolerance.

The *k-factor* describes exactly how the bend elongation occurs. Imagine a cross section of the sheet metal thickness at the bend radius. The outside elongates, the inside compresses, and there's a theoretical neutral axis in between that shifts inward toward the inside radius. Describing that shift is the *k-factor*, which is used to calculate the bend allowance. The nature of that shift varies with material type and tensile strength. The more the neutral axis moves toward the inside radius, the greater the elongation. And all of these variables can be affected by changes in material type, thickness, tensile strength, and even the material grain direction.

As Smith explained, software calculates all this automatically now, but knowing the terms has incredible value, simply because it helps describe exactly how the bend occurs between the punch and die. And it helps clarify communication and keep everyone on the same page.

Next comes the bending method. Air bending has been around for decades at this point, but these days, some bending veterans still grew up in shops that primarily performed bottom bending, where the punch tip determined your radius and the V die angle determined your final bend angle.

Tyler Smith (center), AMADA Bending Academy supervisor, instructs a student during a job setup.

In air bending, the radius is "floated" in the die opening and (for most materials) takes shape as a percentage of the die width, between the die shoulders—as long as your punch tip radius is smaller than the naturally floated radius in the material. In soft aluminum and similar material, the punch tip can determine your radius. When air bending, the depth of penetration—that is, how far the punch tip descends into the die space—determines the bend angle.

2. Tools and Tonnage: One Punch Is Not for All

Smith held up a gooseneck punch, a favorite choice among many operators. "I have students who tell me, 'I was told to use the gooseneck to bend everything.' People are told they're universal tools, but they're not. That's a big misconception."

People choose the gooseneck for its ability to reach a variety of bends. That might be true, but can they effectively form them? Not necessarily.

Smith described tool selection as a process, with each tool choice affecting another. The die width helps determine the forming tonnage a job requires: the smaller the opening and the thicker (and harder) your material, the higher your tonnage.

When it comes to punch selection, he *starts* with tonnage in mind, referring to a bending tonnage chart. Visual aids help here. The pressure flow moves straight down on a standard punch—but not, of course, on a gooseneck, hence its lower tonnage rating.

For this reason, he suggested starting with a standard punch, to see if that punch geometry can safely and effectively form all the required bends. If it can't, he moves on to other punch geometries. For instance, if a bend has a deep return flange, he might resort to a deep gooseneck, looking first at its tonnage rating. If he needs to lower the job's forming tonnage, he might choose a wider V die, as long as the job allows for a larger inside radius.

"Of course, the new machines alarm out and not let you form," Smith said, adding that tonnage considerations are also built into software. Even so, knowing these fundamentals helps operators understand *why* software chooses the tools it does.

3. Know What Makes a Good Bend Sequence

For 90-degree and acute bends, Smith suggested sequencing bends from the outer most bend line inward toward the center. For open bends (inside angles greater than 90 degrees), he bends from the center of the part outward.

Some of the reasoning behind this is intuitive. A good bend sequence allows the operator to slide a flat or partially formed blank solidly against the backgauge. Even an ever-so-slight gap can throw off the bend line position, which can create dimensional tolerance issues that are amplified the more bends you have (stack-up tolerance errors).

When you form a 90-degree bend in the middle of the part first, the remaining bend lines become more difficult to access, and holding the part against the intended gauging point becomes difficult. The part also has a greater chance of becoming trapped within the tooling before the final bend.

An instructor at the AMADA Bending Academy shadows a student during a setup procedure.

Going from the outside inward also helps operators correct for dimensional errors. A good foundation for accurate bending involves a blank with a clean cut edge (with no microtabs that rock against the backgauge) married with a bending sequence that makes it easy for the operator to slide the workpiece solidly against the backgauge. Any unintended movement can alter the bend line position.

Still, errors can occur, especially if bend tolerances are tight and if operators are working with less-accurate machines. (At the AMADA Bending Academy, Smith actually alters the backgauge position slightly, just to simulate less-accurate equipment.) Operators might hold the material solidly against the stops, but material thickness or grain direction variances might alter the bend characteristics. This is why choosing a bend sequence that makes it easy to make slight adjustments to the final bend lines—to keep the part's critical dimensions—works so well.

Now consider a part with a series of open bends. If you were to bend the outermost bend lines to an outside angle of 130 degrees, you likely would have a hard time gauging and positioning subsequent bends. If you start in the center and work outward, you're always gauging against a flat, laser-cut edge.

Smith emphasized that all this is just a starting point, and exceptions abound. What remains important is to imagine the operator (or robot, for that matter) holding a workpiece—safely and comfortably—flat on the die shoulders and solidly against the backgauge and performing a sequence that allows him or her to best hold a part's critical dimensions.

This helps not only at the press brake but also in offline bend simulation. In the real world, gravity works. A large panel with an edge flange needs solid support from multiple operators (which of course isn't ideal), sheet followers, or even a robot with the right gripper. The best sequence allows for the best positioning consistency, bend after bend and part after part.

4. Side-Gauge Your Tapered Bends

Say an engineer designs a part with a tapered bend—that is, a bend line that's not parallel with the part edge or other gauging point. In this case, a shop might choose to mark or scribe the bend line. Smith agreed that this can be a best practice, but it should not encourage multiple operators to "eyeball" the bend—sliding the piece side to side against the backgauges until the scribed bend line matches with the punch tip. The setup needs to be replicated so you can bend accurately from part to part, between operators and between shifts. Eyeballing every tapered bend doesn't achieve this.

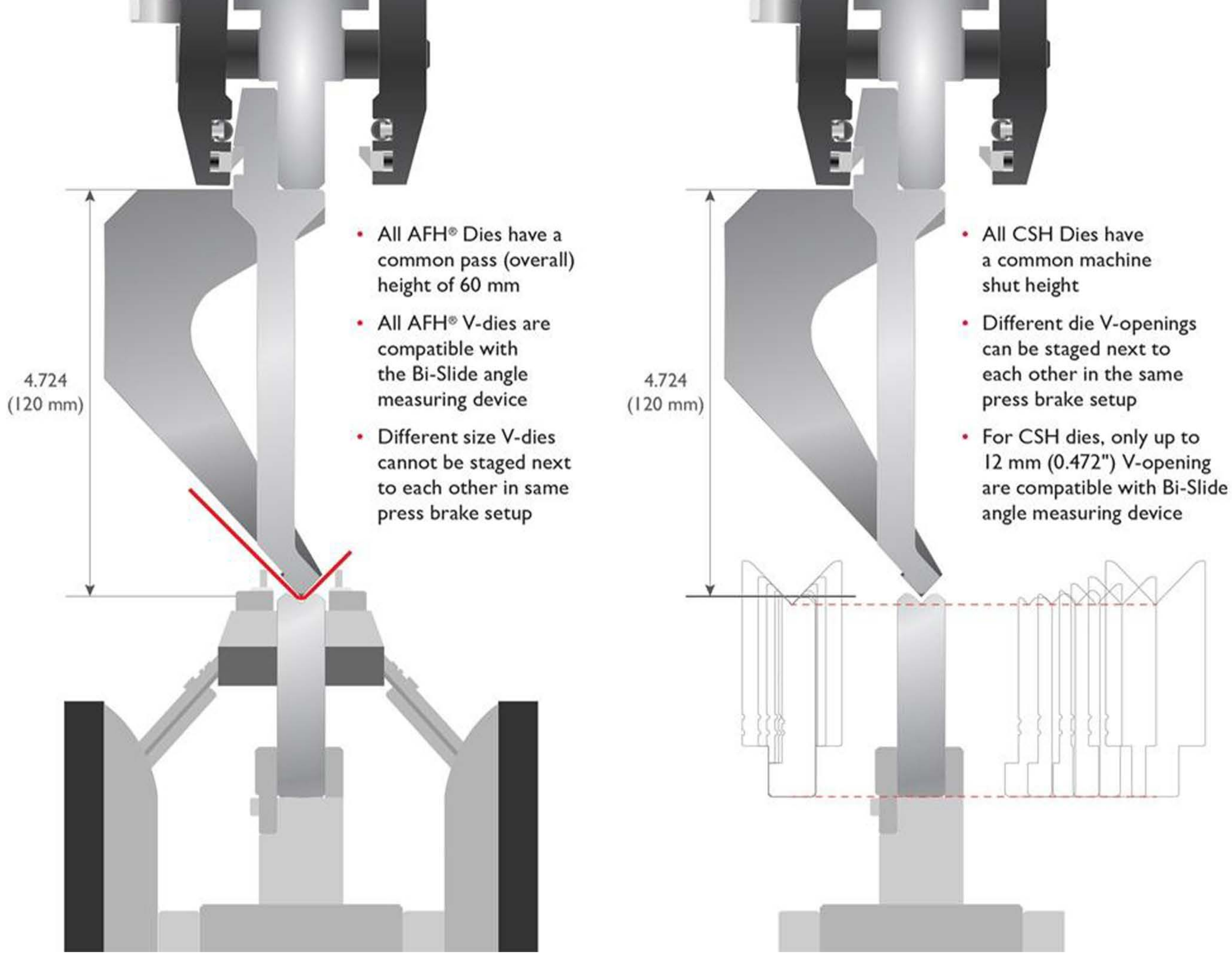
A tapered bend requires left- and right-hand backgauge fingers to be at different distances (L1 and L2). The operator descends the ram to ensure the tip hits the tapered bend line at the proper place. Once established, he or she locks in the gauge position and side gauge, so the position of that tapered bend line remains consistent.

Again, modern equipment, tooling (like wing dies, which prevent "pulling" into the die space), and process automation make such gauging easy and consistent. But as Smith explained, knowing why something works to create a repeatable process—like the use of a side gauge for a tapered bend—is half the battle. That foundational knowledge can help every fabricator make the most out of the latest technology.

5. Stage It Right: Tools, Crowning, and Ram Tilt

Staged bending can turn a multisetup operation into a done-in-one forming job. The first step is to get the right tooling. Fixed-height punches married with common-shut-height dies allow for a single setup to have multiple punch styles and even different V die openings that give you different inside bend radii.

Still, as Smith explained, a staged setup involves more than just the right tooling. It also involves ensuring you have a precise, consistent, and *predictable* depth of penetration into the die across the press brake bed. Modern machines apply *ram tilt* and dynamic crowning to make this happen.



Fixed-height punches have a common pass height. Combined with common-shut-height dies (right), toolsets with different V openings can be staged next to each other.

Yes, ram tilt can help you form over cutouts and create complex bends like cones or funnels, where the bend angle on one side is different than the other. But it also can help with off-center bending on a staged setup. It comes down to physics. The closer you are to the brake's hydraulic cylinders, the applied pressure (tonnage) characteristics change, which in turn can change the resulting bend angle.

The bottom line: Staged bending is a marriage between machine and tooling technology—and ignoring either can lead to serious headaches.

At the Heart of It All

More than a few AMADA Bending Academy classes have hosted laser cutting operators and welders seeking cross-training on the press brake—and there's a good reason for that.

"If you don't get bending right, everything else can fall apart around it," Smith said. "Cutting, bending, welding—they all operate as a system, and each affects the other. And again, bending is in the center of it all."

Smith held up a V die to explain. Again, when air-bending most materials, the radius forms as a percentage of the die opening. Change the die opening, you change your radius.

Change your radius, and you change how the bend elongates the metal (your bend allowance), which in turn changes the bend deduction you need to accommodate that elongation.

All this ultimately changes the blank dimensions in laser cutting and punching. Grain direction (bending with or against it) affects bending too, which can affect how a programmer in cutting nests parts onto a sheet. Then you have thickness variation of a particular gauge, which changes the radius and, hence, everything else.

The right blank with the right characteristics (consistent thickness, optimal grain direction, accurate edges without scalloping, no microtabs that can hit a backgauge) creates optimal bending accuracy and, in turn, a formed part that mates perfectly for manual or robotic welding. The better that accuracy, the better the weld, which can open the door to better welding efficiency and even more advanced welding processes—including laser welding, which often eliminates the need for grinding and polishing.

Considering the wide-ranging, cascading effects of bending, press brake operators soon realize just how critical their jobs are. Organizing and maintaining tools (including some basic 5S), keeping them clean and free of metal shards (which can mark workpieces and damage tool surfaces), now just seems like a no-brainer.

Put another way, dialing in a bending operation effectively gives a fabricator a healthy heart that's ready for everything—including advanced levels of automation. Knowledge of the fundamentals reveals just how valuable the different kinds of bend automation, from ATCs to robotic bend cells, really are. A fabricator could make advanced use of AMRs, cobots, traditional robots, parts picking and material handling automation—even robot vision, which can identify and start processing parts autonomously.

All this becomes possible when a blank can be positioned precisely over a die, securely against a backgauge, in the right press brake with the right tooling that can form the required radius and bend angle to the required level of precision. “If you know your bending operation, you know cutting and you know welding,” Smith said. “That’s what keeps me coming into work every day. Forming really is at the heart of what we do.”

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Tim Heston, The Fabricator's senior editor, has covered the metal fabrication industry since 1998, starting his career at the American Welding Society's Welding Journal. Since then he has covered the full range of metal fabrication processes, from stamping, bending, and cutting to grinding and polishing. He joined The Fabricator's staff in October 2007.

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