

LEARNING MADE EASY



Fabricating

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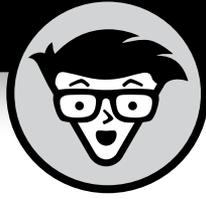
Learn forming, stamping,
and sheet-metal processes

Pick up best practices and
important application advice

Compare laser cutters
and hybrid machines

Kip Hanson

Freelance Technology Writer and
Manufacturing Consultant



Fabricating

by Kip Hanson

for
dummies[®]
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Fabricating For Dummies®

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Introduction

Step onto the front porch. Take a look around. There's the teenager across the street, patiently pounding the quarter panels on her 1969 Volkswagen Beetle into shape, then sanding the metal bare so she can apply a little primer paint. That bug's going to be a beauty when she's done.

The kids two houses over are constructing a treehouse, nailing and screwing together the stray bits of sheet metal and scrap lumber found at the housing development five blocks down. Their arboreal creation is sure to block what's left of your sunset views. Have to talk to their dad about that.

And then there's the bridge project on the interstate. It's been going on all summer — the endless, inexplicable welding and cutting and pouring that promises to lop fifteen minutes off your commute when finished.

These are a few of the everyday examples of fabricating. It's going on all the time, all around us, and it's an important part of our lives. Without fabricating, there'd be no central air conditioning in our homes, no kitchen appliances, no car in the garage. None of that would really matter though, because modern day conveniences like gas stations and food processing plants wouldn't exist, let alone windows and doors on the house.

You might be able to catch a chicken for dinner and club it with a rock, but you'd need a stone knife to prepare the thing before you could huddle around the fire with the family to eat it. Strip malls and skyscrapers, farm tractors and fryer baskets, prescription drugs and polyester ski jackets . . . fabricating makes it all possible.

Even the paper airplanes you made as a kid (and might still be making). That's fabricating (albeit of paper rather than metal). Sewn a dress or made an Iron Man-like suit of armor? Yep, both fabricating. Spent all weekend assembling and then reassembling a metal shed because you didn't read the instructions the first time? That is an example of fabricating followed by reworking, an unpopular term in any fab shop.

Still, what exactly does “fabricate” mean? A quick Google search says it’s a transitive verb (I shouldn’t have slept through English class, as I’m still unsure about the transitive part) used to describe the following acts:

- » Inventing or concocting (something), typically with deceitful intent
- » Constructing or manufacturing (something, especially an industrial product), especially from prepared components

Well, the first definition doesn’t apply at all to the fabricating I’m talking about. Sorry, Merriam-Webster. The only deceitful intent you might find in a fab shop is someone sneaking out a few minutes early on Friday for happy hour with his or her coworkers. As for the second description, the fabricating I discuss in this book is more about actually making those “prepared components” than it is about bolting or gluing or welding them together (although assembly is certainly a familiar process at most fab shops).

Granted, it’s a broad term. Civic construction projects, autobody repair, bridge building, and pipeline laying — technically speaking, these fall into the general category called *fabricating*, and are performed by companies with fabricating as part of their business name, but much of that work falls outside the context of this book.

For the purposes of this book, “fabricating” and “fabrication” and sometimes just plain old “fab” are meant to describe that subset of metalworking concerned with forming, bending, cutting, drilling, finishing, and otherwise manipulating sheets of metal (tubes and pipes pop up occasionally as well, as does welding and even machining).

Whether you’re looking for a new profession (one with plenty of eager employers) or just want to know how the heck refrigerators and jungle gyms are made, this book is for you. You’ll find out about the machines that shape metal, the tools that slice and form it, the robots that lift it, the software that figures out the best way to process it, along with a few mandatory historical tidbits you can share with your friends in your Thursday night bowling league. So get reading.

About This Book

To borrow a cliché, fabricating has a lot of moving pieces. That’s why *Fabricating For Dummies* is broken up into bite-sized ones. Part 1 provides a high-level overview of the different fabricating processes, the metals used in those processes,

along with a little bit of metalworking history (but don't let that scare you). Part 2 dives deeper into the specifics of punch presses, stampers, and other fabricating equipment, while Part 3 talks about auxiliary topics such as automation, welding, and software. And of course, no *For Dummies* book would be complete without a Part of Tens, which in this case offers advice and information on a variety of manufacturing areas.

All in all, *Fabricating For Dummies* covers half a dozen or so distinct metalworking processes, along with measuring, painting, grinding, toolmaking, and a little machine-tool programming. There's even a little history inside, but you can skip those parts if you really don't care about the accomplishments of others.

I hope that's not true, though, because where would we be without Abraham Lincoln, John F. Kennedy, Alfred E. Neuman (What? Me worry?), and all the other important people without whom modern society wouldn't exist. The same goes for the men and women who work in our manufacturing plants every day, who bend, shape, cut, and assemble the products that make our lives safe and comfortable. You guys and gals are the best.

Foolish Assumptions

This book assumes you're interested in fabricating and metalworking. There are no prerequisite skills needed, such as being able to build a shed or having once straightened a dented fender on your lime green Kia Soul, to understand the concepts discussed herein. If you have been yelled at by your mom for using her manicure scissors to trim the dog's nails, you already have a leg up on fabricating (the first machine I ever ran was a shear, a 12-foot long version of mom's clippers). If you installed a garage door or cut and soldered some new pipes in the bathroom, better yet. Oh, and you should know the difference between metal and other everyday materials like plastic and wood (metal is the hard, shiny stuff).

And since the majority of all machines these days are controlled by computers, you hopefully know what one is, and understand that they are actually in charge of everything around us and will one day enslave all humanity. But that's years in the future. For now, knowing what I mean when I use geeky terms like "network" and "software" will see you through the book just fine.

Icons Used in This Book



TIP

My dad's full of good advice. Don't stand up in a canoe. Drink more water. If you can do something in less than five minutes, do it now. A fool who can keep his mouth shut is counted amongst the wise. You can outrun the cop, but not the radio (actually, I found this one out on my own). I can't compete with Dad's nine decades of wisdom, but once in a while I pull an anecdotal rabbit out of my hat like, "Write it down because you won't remember it in the morning." Keep an eye out for the Tip icon for more of these gems.



TECHNICAL
STUFF

Manufacturing technology continues to become easier for us simple humans to master, but it's still pretty darn technical at times. For example, did you know that fiber lasers work best when nitrogen is used as an assist gas, or that the tools used in turret punches should be demagnetized before use? See? That's what I mean. It's important information. That's why there are all these Technical Stuff icons scattered throughout the book.



REMEMBER

They say elephants never forget. If I were an elephant, all the other elephants in the herd would make fun of me, because I can't remember Jack (or Jill, for that matter). If you, too, suffer from CRS (can't remember . . . stuff), feel free to lean on the Remember icons you'll find in the coming chapters (assuming I don't forget to put them in).



WARNING

Machines have moving parts, often moving up and down faster than a seamstress's needle. Visit the Old Fabricators' Retirement Villa and you're sure to see plenty of truncated thumbs and more eye patches than at a pirate convention. Fortunately, fabricating has become far safer over the years, but that doesn't mean you should be careless. Watch for the Warning icons if you want to retire with all your digits.



IMPORTANT
DETAILS

Stop for red lights. Tip the waiters if you want good service next time. Let sleeping dogs lie (that might have been one of my dad's tidbits). Whatever the case, these are a few examples of life's important details, some of which are explained to us by friends and family, while others are learned through trial and error. In this book, be sure to read the information in Important Details if you want to avoid finding things out the hard way.

Beyond the Book

Can't get enough of fabricating? I get it, really, which is why this book comes with a free access-anywhere Cheat Sheet that offers additional tips on laser cutting, press brakes, welding, and robots, and how to get to the Old Fabricators'

Retirement Villa safely. To get your very own copy of this Cheat Sheet (suitable for framing), head on over to www.dummies.com and type *Fabricating For Dummies Cheat Sheet* in the Search box.

Where to Go from Here

If you haven't yet figured out what you want to be when you grow up (don't worry, it took me a few decades), then this book might be the turning point. You can forget about majoring in history. Set aside your plans to own a floral shop. Mrs. Carnahan, thanks for driving the school bus, but fabricating might have been a more rewarding career choice. The pay is better and no one puts gum on your seat.

You can start by checking out the local vocational school. If your instructor's an old-timer, you might learn about manual sheet-metal layout using Dykem (a nice-smelling though noxious blue dye), a scribe, and a marking punch, but once that now largely unnecessary lesson is behind you, you can move beyond the basics to stuff like bending allowances and how to set up a turret punch.

Check out the Fabricators & Manufacturers Association (www.fmanet.org) website for participating trade and technical schools, or if you're a veteran, cruise over to Manufacturing Day (www.mfgday.com/blog/future-veterans-manufacturing) or give Workshops for Warriors in San Diego a call (<https://workshopsforwarriors.org>). They have some awesome programs available for transitioning service members, and you can spend your weekends learning how to ride a boogie board and find out when it's appropriate to say "gnarly, dude."

And if you're content with your current job, congratulations. Fabricating is still a nifty hobby, and if you want to learn how to bend up a galvanized steel doghouse for your prize-winning Pekingese, what better way to get started than by reading this book? Either way, it's time to march up to the counter, hand over your hard-earned cash to buy this book (or enter your credit card number on whatever bookseller's website you're currently surfing) and read it from start to finish. Get going.

1 Fabricating Truths

IN THIS PART . . .

Buzz the tower of common fabricating technologies. Don't worry; it's perfectly safe.

Learn the importance fabricating has to your everyday life and why there'd be no cars, appliances, or lawn furniture without it.

Cruise through a short fabricating history lesson and learn interesting facts about a bunch of ingenious, mechanically-minded people.

Explore metal sheet, plate, and tubing, gaining great appreciation for hardware stores and metal supermarkets along the way.

IN THIS CHAPTER

- » Introducing basic metalworking processes
- » Understanding the difference between bending and forming
- » Comparing fabrication to other manufacturing processes
- » Taking apart the machine for a peek inside

Chapter 1

Manipulating Metal

It is not knowledge, but the act of learning, not possession but the act of getting there, which grants the greatest enjoyment.

— CARL FRIEDRICH GAUSS

In 1987, ex-Beatle George Harrison released the hit song, “When We Was Fab,” in which he lamented the loss of his youth and the subsequent breakup of the original boy band from Liverpool. In spite of his poor grammar (or perhaps in part because of it), Harrison’s tune caught on. Although it might sound silly, I can’t listen to the late musician’s hit single without thinking about the fabrication, or fab, shop where I once worked, the sounds of stamping presses and laser cutters rattling about behind my ears. Am I crazy, or is that a sign of too many years making parts?

It’s certainly not the latter. Metalworking is an awesomely cool profession (albeit one that’s a bit noisy), and I wouldn’t trade the memories of those sounds and smells for anything. Walk into any fab shop and you’ll immediately know what I’m talking about — the boom . . .boom . . . boom of the heavy stampers reverberating through the floor like the footsteps of a not-so-distant giant.

From the other side of the factory comes the machine-gun sound of the turret presses, the crackle of the welders, and the hiss of lasers and waterjets and high-density (also known as high-definition) plasma cutting machines patiently slicing through steel. It’s an awesome experience. Yes, it can be a loud place

(be sure to wear your hearing protection), but there are some wondrous things going on here; metal is being shaped and stamped and sliced and bent into parts that are used all over the world and held to tolerances finer than the thickness of a human hair.

Defining the Processes

Even more so than those shops that cut metal on lathes and machining centers each day (that is, machine shops), every fabrication shop is different. Where some specialize in welding large metal structures like electrical distribution towers and railroad trestles, others cater to customers looking for hydro-formed parts or millions upon millions of stamped-metal widgets.

The term *fabricating* covers a diverse set of technologies, some performed on generic machine tools that might accommodate dozens of distinct processes, others on specialty equipment that does only one thing. I dive more deeply into the more common of these processes in Part 2, but for now, let's take a 30,000-foot view of all that it might mean to be a fabricator, starting with *cutting*, a generic term that includes cutting metal with a stream of high-pressure water, a high-powered laser, or a jet of super-hot plasma, and is one of the primary operations performed on sheet metal, plate stock, angles and shapes, and billets.

Cutting up

Look up the word “cut” in the dictionary and you'll see it described as “using a sharp instrument to sever, slice, or chop” something, as in “I cut my big toe on the doorjamb last night.” Ouch. When it comes to sheet metal, however, cutting generally means fracturing the material — no sharp edges are needed, at least not like the tip of a kitchen paring knife.



TECHNICAL
STUFF

Punching and shearing operations usually require two precision-ground edges to be slid past one another, often at a high rate of speed but not always so. As they pass, the material trapped between these opposing forces deforms momentarily and then fractures, whereupon a section of raw material literally breaks away from the sheet, plate, or angle from which the workpiece is being made. Examples include the punch and die set used to punch out millions of shiny new pennies, or a huge scissors-like machine tool known as a *shear* (something I *slice* into shortly).

To be completely accurate, much of the “cutting” done in the fabricating world is actually a shearing operation of some sort, although that's not to say you can't cut a piece of material with a bandsaw — it's done all the time but is generally

reserved for materials too thick to shear using conventional means, or by shops that don't have a heavy-tonnage shear.

Even though the mechanisms are fundamentally different, the term *cutting* has also come to encompass newer technologies such as abrasive waterjet machines and laser cutters, both of which are giving their centuries-old shearing counterparts a run for their money (see Figure 1-1).



FIGURE 1-1: Abrasive waterjet machines can quickly and cleanly cut virtually any material in any thickness, from the hardest steel to the most friable stone.

Courtesy: WARDJet, Inc.

Shearing specifics

My wife owns a set of heavy-duty kitchen shears. She hides them in the drawer behind the Ziploc bags, and occasionally inside her nightstand drawer. I love those shears, and even though she yells at me for doing it, I use them to cut everything. Aluminum foil, cardboard, rope, that nearly-impossible-to-open plastic packaging that once contained my latest Captain America figurine — you name it, they cut it.

But shears do far more than create domestic disputes in the kitchen. Industrial shears are just as important to those who process sheet metal for a living. They function in much the same manner as their smaller household counterparts, by passing a blade of hardened steel past a stationary but similarly shaped blade

below. This fractures the metal, and if all has been set up properly, will leave a straight, clean edge with minimal burr. (Burr is those annoying, ragged, and often sharp edges that can send the incautious among us to the emergency room for stitches.)



TIP

Suppose you want to make a replacement electronics cabinet for your vintage Elvis Presley pinball machine. You might start with a 4-x-8-foot sheet of aluminum, shear off a piece to match the cabinet's "unfolded" dimensions, notch out the corners (perhaps using a punch press), bend it up on a press brake, and then spot weld the corners together. The King is back in business. (I talk more about these operations in Part 2.)

Slitting success

Pretend it's your favorite nephew's birthday and you want to wrap the *For Dummies* book you're giving to him as a gift. The roll of paper is 36 inches across — far too wide for that yellow-bound work of art — so you decide to slice the paper in half lengthwise. If the gift wrap were made of steel, you would have just performed a slitting operation, and it's the first step in the process that turns coils of steel perhaps six feet wide, thousands of feet long, and weighing tens of thousands of pounds into more manageable pieces of raw material (check out Figure 1-2).



FIGURE 1-2: Every day, metal coils weighing more than a school bus are slit, sheared, stamped, and formed into millions of different parts.

mady70/Shutterstock

Slitting is a type of shearing operation, except it's usually done continuously, lengthwise down the coil. A single coil might be unwound, slit into whatever widths are needed, then rewound again on the opposite side of the slitter in one continuous process. It could also be used to feed a stamping line — flattened and sheared into short lengths to make sheet stock for use on a turret punch or laser cutter — or sent to a blanking line as the first step in the production of the door panel for the new sports car you're planning to buy next year.

Punching out

The mechanics of punching are much like those of shearing in that the metal is first deformed and then fractured in rapid succession as the tool moves past. But where shearing uses a set of opposing blade-like tools to get the job done, *punching* relies on a punch and die set (hence the name) that fit together precisely, one within the other (Figure 1-3 shows a photo of one such tool).

FIGURE 1-3: As the name implies, these multitools contain multiple punch and die sets, which can be indexed to whichever tool is needed. They are a favorite of turret punch-press operators who've run out of tool stations.



Courtesy: Wilson Tool International

Suppose you want to make a series of Mickey Mouse-shaped holes in a sheet of aluminum. (I'm unsure why you would want to do this, but you get the idea.) Accomplishing this task would require a punch made of hardened tool steel or tungsten carbide (sometimes simply called "carbide"), which in all likelihood was

cut using a wire electrical discharge machining (WEDM) machine to resemble everyone's favorite rodent. (I talk about EDM and other toolmaking processes in Chapter 12.)

The punch will be mounted in the top station of a punch press or possibly in the upper half of a stamping die. In either case, a mating female die must be positioned directly below it. Some small amount of clearance (less than a hair's width, most likely) between the punch and die is required for machine misalignment and to allow the slug to pass through, with thicker materials requiring commensurately more clearance than when punching thin materials. Slide the material between the two halves of the mating tools, give the punch a whack, and there's Mickey.

Perforating

Here's another punching example. Most of us who live in the desert Southwest have a security screen door on the front of our house to allow fresh air in while keeping critters such as coyotes and javelinas (which look like wild pigs) out. These doors are made of perforated metal — it resembles a window screen but is thicker and strong enough to withstand inquisitive noses. Perforated metal is also used for washer and dryer drums, screens for separating materials in food processing, and as decorative panels in architecture.

Perforated metal is produced in a variety of ways. The most common employs a device that looks similar to a rolling pin that has a series of sharp needle-like punches around its circumference. As this “perforation roller” rolls over the metal, it continuously punches round, square, or whatever-shape holes are desired along its surface. Now take this concept one step further. Rather than a cylindrical roller, it's quite feasible to produce the holes en masse via a metal plate that looks like a bed of nails and a matching die set. Just give the sheet a good whack as it passes beneath and thousands of perforations can be made in one shot.



IMPORTANT
DETAILS

Expanded metal is a close cousin to perforated metal. Like chicken wire on steroids, it's great stuff for non-slip surfaces on industrial walkways and running boards on monster trucks. And to borrow another example from the desert Southwest, expanded metal lath is commonly applied to the outside of houses before slathering them with stucco. Rather than simply punching holes and diamond shapes as with perforated metal, however, expanded metal is made by simultaneously stretching the metal while punching small slits into it, much like the process we once used to make paper snowflakes as children. (It's perfectly okay if you still do so.)

Blanking

As I mention a few pages back, sheet metal starts out as humungous coils of material that are delivered from the mill to a metal processor. These are then

sliced into narrower coils or sheared and flattened into manageable pieces approximately the size of the plywood sheets you've probably purchased at one time or another from the local lumber yard.

In either case, the sheet stock is often “blanked” into a variety of shapes that are sent on to secondary processes. For high-volume applications such as automotive door panels, this is usually accomplished using a punch and die on a dedicated blanking line. A punch of the desired shape is forced through the sheet and into a mating die. This shears the door panel out of the sheet, causing it to fall through.

What's the difference between a blanking operation and, say, cutting an oblong-shaped window or punching a hole in a workpiece? Easy. With blanking, the piece that falls through the sheet *is* the workpiece, whereas in a normal piercing or punching operation, that leftover chunk of material is scrap.



REMEMBER

For higher-volume shops, blanking is often done with a punch and die set, but shops could also use a laser, waterjet, or shear to knock out whatever shape is needed for the forming press or press brake. The decision as to which is most cost-effective largely depends on job quantity, edge quality, material thickness and type of material, and which machine is most readily available.

Boarding the Bending Express

Virtually all sheet metal is bent or formed into some sort of shape eventually. If not, it would just lie there being flat for its entire life, good for little more than a gasket or shim. Boring, right? Most of the time, bending operations belong to the press-brake department, but that doesn't mean you can't bend a bracket with a die set in a stamping press, or fold a short, shallow louver using a special tool in a turret punch press. Fabricators are clever people, and they are constantly coming up with ways to make their equipment work for them.

Putting on the brakes

Bend a piece of metal too far or too fast and it will *fracture*, which is the same mechanism involved in shearing. But by controlling it carefully (and by selecting metal that boasts sufficient plasticity), precise, high-quality bends can be made in a variety of metals.

I get into the nitty-gritty details of press brakes in Chapter 5, but for now, you can think of one as a big paper airplane folding mechanism with a V-shaped (usually) punch on the upper side of the press and a mating female die on the bottom. Squeeze a sheet of metal between the two halves and a variety of shapes can be formed.

There's way more to the story than this. Accurate tonnage and bend calculations, the types of tooling used, blank size, corner radii and part dimensions, and the order in which bends are made all play a role in the success of any bending operation. Check out Figure 1-4 for an in-process photo.

FIGURE 1-4: Bending complex parts like this is all in a day's work for a modern computer numerical control (CNC) press brake.



Courtesy: LVD Stripit

Forming opinions

Step out to the garage for a moment to groove on the sleek lines of your 1991 Yugo GV. The quarter panels, hood, roof, doors, and even some parts of the frame were made on a stamping press larger than a studio apartment. (Sadly, the Serbian plant that once made the Yugo was destroyed by NATO bombs in 1999.) Heavy stampers work much like press brakes, except that rather than bending up a box one edge at a time, the heavy stamper would form the entire box in one shot: BOOM!

Just kidding — it would be impractical to form a box shape in this manner, as the corners are too sharp and the metal would buckle. But heavy stampers can form very complex shapes. Just drive down the street and admire the far sexier curves of cars thirty years newer than the boxy, Yugoslavian automotive marvel tucked away in your garage.