"If it isn't there, it doesn't cost anything. This applies, above all, to sheet thicknesses and the number of single parts that make up a component."
Lutz Hartmann, Design

CREATING ECONOMICAL DESIGNS

The maximum allowable cost of a sheet metal part is determined before work begins on designing the part. Naturally, the more economical the part is, the better. There are two ways of achieving this. You can either save on material or cut costs in production. "Economical," however, is not the same as "cheap." The goal is to combine the various production factors – the type of material, material consumption, time, machines, and tools – in the best way possible.

Production factors influence each other. One change can oftentimes have a positive effect on a number of different areas. For example, a reduction in the number of single parts used to create a module not only saves material, but also reduces production time. The following methods have proven to be successful in creating economical designs:

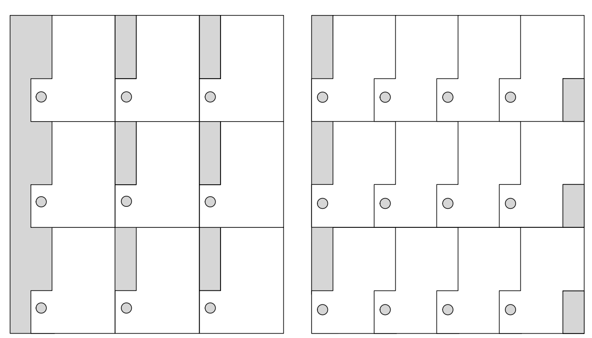
Minimize sheet thickness | Save material by selecting the smallest sheet thickness possible. This means lower material costs, reduced part weight, and faster production.

Use the same sheet thickness | Wherever possible, the single parts making up a component should all have the same sheet thickness, so that they can be produced from a single sheet in one work cycle. When this is done, an entire sheet can be used for flat processing instead of portions of several different sheets. This is especially important for small sheet metal fabricators who handle each job individually. It not only makes purchasing and storage easier, but also cuts down on transport between the storage bay and the machine. Also, it takes less time to set up the machine.

Maximize nesting potential | Everything left over after the parts are punched or cut out of the sheet is scrap. This includes the sheet skeleton remaining between the parts and the cutouts that are produced when holes are cut in the workpiece. Design engineers can fit more parts on the sheet by designing the parts so that they "nest" inside each other. Depending on the design, it may be possible to fit smaller parts inside some of the larger cutouts. Enlarging a notch on the outside contour may also allow parts to be nested closer together. Parts with straight contours can be placed right next to each other and separated with a single cut. This helps to reduce scrap.

The benefits of these methods are particularly apparent when manufacturing parts in large quantities or producing sets of parts for use as components in sheet metal modules.

One part, many functions | In many cases, the sheet metal part can be designed to fulfill two or more functions. Often, these parts only need some additional holes or larger recesses in order to perform a different task. Advantages: larger quantities can be produced and only one storage location is needed.



Using design to reduce scrap: designing parts so that they nest closer to one another is a way to maximize sheet utilization.

Minimize the number of single parts | As a general rule, it is better if components comprise a small number of complex parts than a large number of simple parts. This is because joining processes are usually very time consuming. Today's manufacturing techniques and programming software make it easy to produce even complex single parts.

Why weld when you can bend? | Welding not only takes up valuable time, but also generates heat that could potentially warp the workpiece. For this reason, it is always a good idea to check whether an attached part can be substituted by simply bending another section. This eliminates the need for welding along with all the associated prep work such as setting up, aligning, and clamping the parts.

Minimize cleanup | Cleanup work can be reduced by eliminating welding seams entirely, by welding sections from the inside, or by designing edges so that they are straight and smooth after welding. New manufacturing techniques such as laser welding also help to reduce cleanup wor'

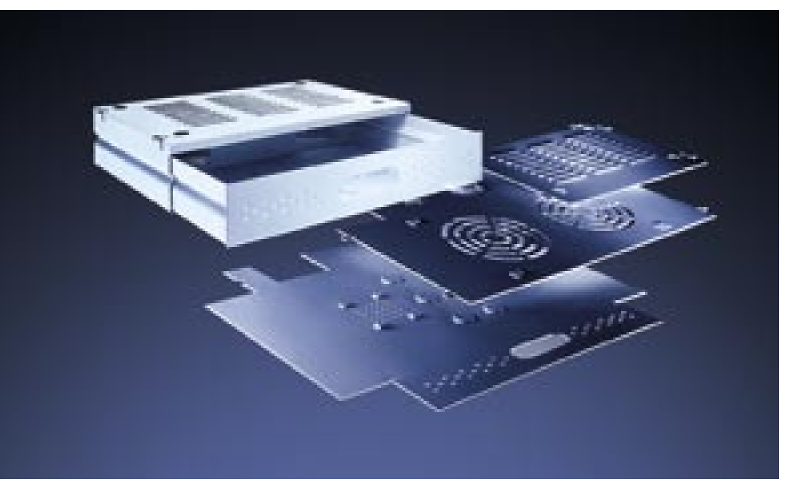
1 The visible edges of this cover are welded together using a laser. The welding seams are clean and smooth, eliminating the need for extra cleanup work.

Alternatives to welding: flanges can be bent and side elements can be secured in place using pegs that fit into holes.

YOU DESIGNED IT. NOW CAN YOU PRODUCE IT?
When designing a part, design engineers not only have to keep in mind the function and cost of the part, but also how it is going to be manufactured. Here, there are a number of different strategies that engineers can rely on.

Allow extra space for bending zones | When a sheet is bent, the metal on the inside of the bend is compressed. This causes the material at both ends of the bend to be pushed outward, which, in turn, may lead to inaccuracies. To prevent this from happening, small recesses are designed into the ends of the bending zones so as to provide extra space for deformation.

Extra space is frequently provided for bending zones, regardless of whether two edges meet at a corner or whether a flange is bent upwards. This produces much better corners, while permitting greater freedom in the selection and arrangement of bending tools.



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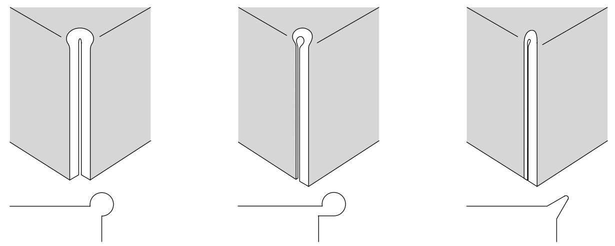


Certain areas can be notched in order to obtain better corners.

There are a number of ways to create extra space for bending zones. A punch press can be used to punch round holes at both ends of the bending line. Or a laser can be used to cut fillets, which are more complex. This makes corners more attractive after the parts are bent.

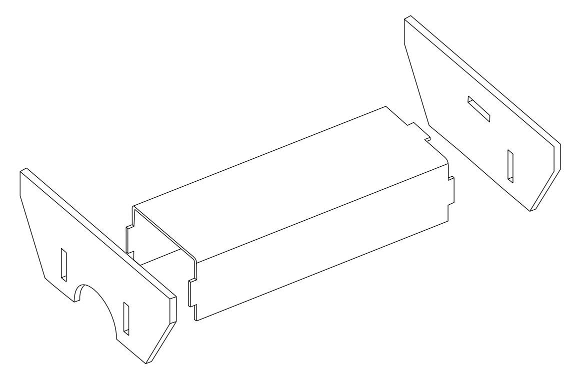
Use existing tools | Especially when it comes to small and medium-sized quantities, acquiring new tools is not a worthwhile investment for a company. In most cases, it is not even necessary. For many shapes and functions, there is more than one alternative. It is the design engineer's job to find the alternatives that make do with existing tools.

A good example is the ventilation holes on a PC housing. A punch press that permits tool rotation can be used to arrange simple oblong holes in a radial pattern. An alternative would be to arrange small squares in rows or use a louver tool to produce ventilation slots.

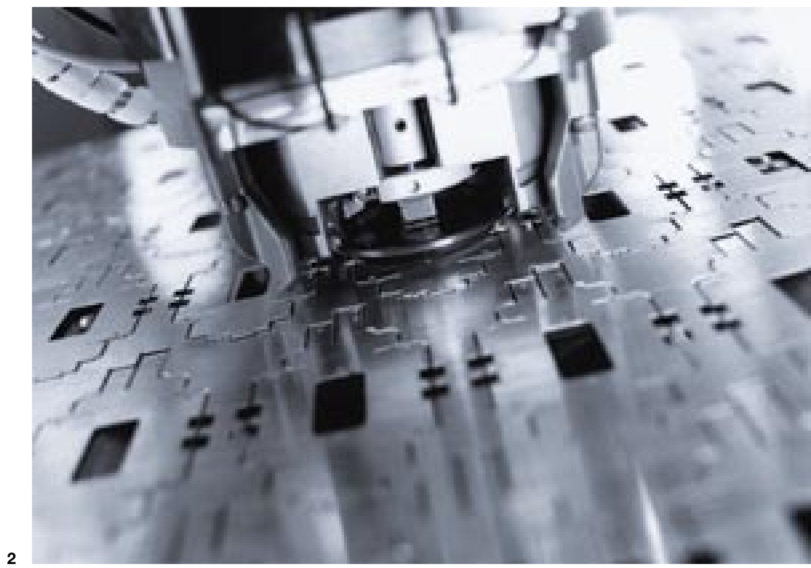
Use positioning and joining aids | Where was the part supposed to go again? Was it on the left or the right? Questions like these can be avoided by designing the parts so that there is only one way to put them together. This is done by using matching holes and pegs to assemble parts. At the same time, there are certain joining techniques that reduce the amount of prep work involved in processes such as welding. Instead of using a device to position multiple parts and secure them in place, you start by fitting the matching parts together. Now all that is needed is a simple welding jig to hold the parts securely in place.

Microjoints | The idea of using microjoints was a solution initially developed for laser cutting. Microjoints are narrow tabs located between the workpiece and the sheet. They hold the workpiece in the sheet and keep it from becoming displaced. After the sheet has been processed, the parts are snapped out of the sheet by hand.

There are other ways that microjoints can be used. For example, they can serve as production aids in the manufacture of small angles. The blanks remain connected by microjoints. They are bent together and then separated by hand. Another example is creating bends in parts where accuracy is not crucial. Microjoints are placed along the bending line, making it possible to bend the parts by hand.



Joining made easy: there is only one way of joining the parts together.



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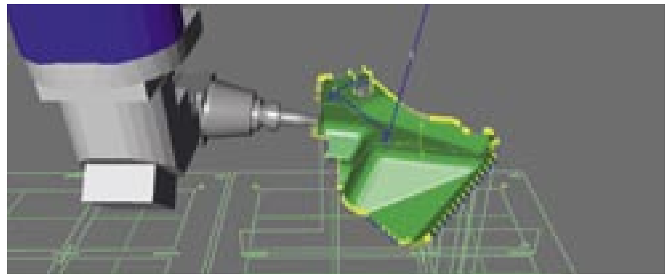
1 Housing with different ventilation openings
2 Microjoints: thin support pieces keep punched parts from falling out of the sheet skeleton.

Everything on the punch press | When solid parts are substituted by sheet metal parts, these parts often still require machining of some kind. Holes still have to be drilled, and threads have to be cut. The most cost-effective solutions, however, do not require any cutting at all. This can be done, for example, by using the punch press to form threads instead of cutting them.

Life after production | The true life of a sheet metal part actually begins after production. For this reason, it is important for design engineers to take into account aspects such as transportation, storage, assembly and disassembly. For example, parts that are transported and stored in large numbers should be designed so that they can be stacked on top of each other to save space.

1 Virtual manufacturing: the movement of the laser cutting head is simulated on a computer.



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Production simulations | Many types of design and programming software enable users to simulate production. This allows design engineers to test sheet metal parts as often as necessary to identify problems. Today, computer simulation has become an indispensable pre-production tool, particularly for the manufacture of complex parts.

The use of simulations ensures that workers in production no longer have to stand next to the machine for hours trying to figure out the optimum production sequence for a sample piece. Company directors will also be pleased to see that the machine is being used to produce something instead of completing endless test runs.

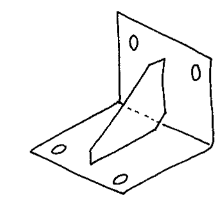
Knowledge transfer | Design engineers who have extensive experience in the field are able to rely on their expertise to tackle each new task. Working together with colleagues in production, they have gained knowledge of the attainable tolerances and learned which hole spacings, edge formats, side lengths, and bending radii work and which ones don't. To ensure that this knowledge can be used by others, it has to be documented. Ideally, this is done using the design software, which helps to integrate individual experience and safeguard company standards.

FIVE WAYS TO PRODUCE AN ANGLE

Design is an art. Designers not only have to know plenty of good tricks, but also when to use them. Sheet metal is so versatile and the parts are often so complex that engineers may not immediately recognize all the possibilities. Jörg Heusel, design engineer and instructor at TRUMPF Werkzeugmaschinen GmbH + Co. KG in Ditzingen, knows just how challenging this can be. He conducts workshops in which participants search for new solutions for their existing parts. "The people in my workshops frequently ask me to demonstrate the many possibilities available using only a simple example," says Jörg Heusel. His response is to show them five ways to produce an angle. Angles are always positioned in areas where two surfaces meet. They hold the surfaces in place and help support them when they are stressed. If the angle is subjected to extreme loads, it may need to be reinforced. There are many different ways of doing this.

Method 1 | Using cross braces The first way to make angles sturdier is to weld a cross brace down the middle of the angle. What this means for production: two parts have to be punched or cut with a laser; the angle is bent; and the cross brace is positioned and welded to the angle, producing two seams. Not bad, but how can we find a better solution?

Method 2 | Using joining aids This method is aimed at reducing the amount of positioning and welding work. The cross brace has two tabs, and the angle has two rectangular slots. The tabs are inserted into the slots, and the joint is welded from the outside at two points.



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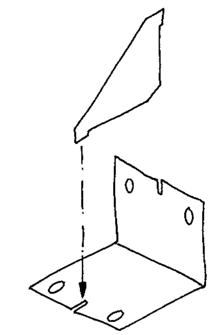
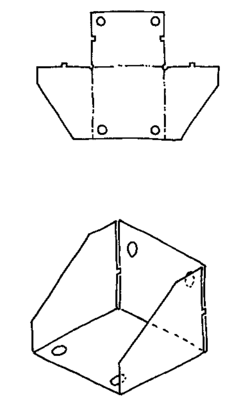
Angle with welded cross brace for reinforcement



2
The cross brace has tabs that help to join parts.



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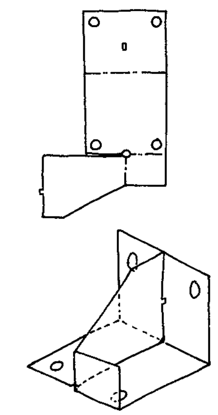
One-piece design: sides instead of cross brace.



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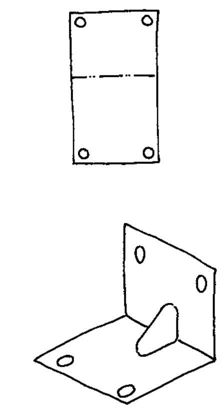
Three bends are used to produce a center brace.



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One bend only: cross beading instead of cross brace

Method 3 | One part only Two parts generally mean more work than one part, because they are often produced separately and then put into temporary storage. So let's try using one part instead of two. Two supports on the sides of the angle now replace the cross brace. As before, these sides are also designed with joining aids that facilitate welding. The angle is punched or laser cut and then bent three times. The sides are then welded. Although we have not significantly reduced the amount of work required to produce the angle, we now have a part that is very robust.

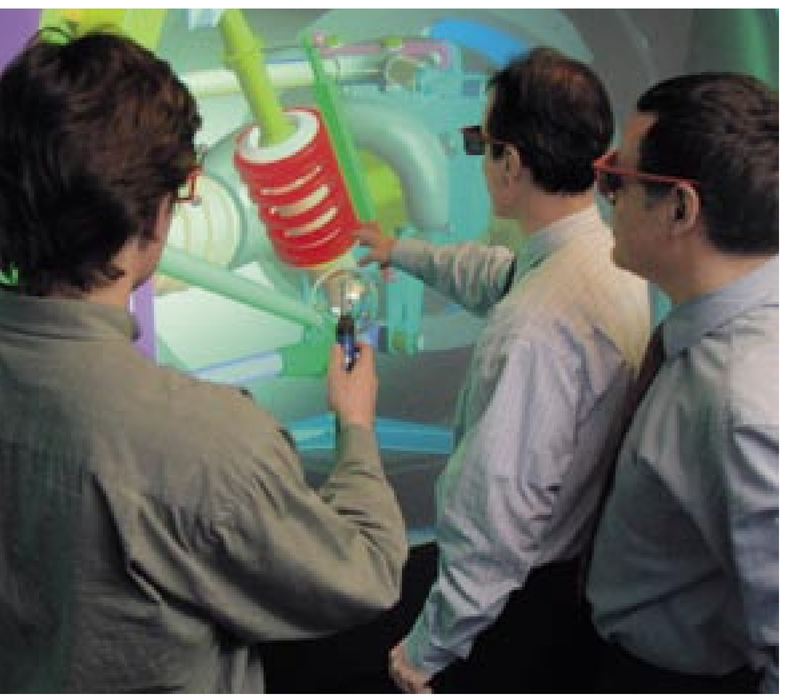
Method 4 | The answer is just around the corner So what do you do if the brace absolutely has to be positioned down the middle of the angle? The solution is easier than you might think. This time, two bends are made to bring the brace into position. Here, too, a tab is used to fit the brace to the angle. This results in a single part that requires only three bends. Now, all that's left to do is to weld the brace at one single point.

Method 5 | Don't forget what the part's made for Let's look back for a moment at the function of the angle. It has to be sturdy and be able to support a load. Wait, does the angle even need a cross brace? Or would a simple, well-placed corrugation do the trick? If cross beading is enough, you could consider first punching or cutting the rectangular parts from the sheet. Afterwards, the edge and corrugation can be produced in a single bending process. This approach not only minimizes production time, but also makes it possible to stack and store parts to save space.

Creative in cyberspace

The changing nature of the job | The job of a design engineer is constantly changing. Each new material, tool, and manufacturing technique adds to the ever-growing array of design possibilities for sheet metal parts. At the same time, new design software and virtual modeling methods are changing the way design engineers work. Even so, it usually takes years before new technology becomes known among professionals in the field and is then applied.

Many companies feel that the engineering design programs offered by various schools do not give enough attention to sheet metal design. To fill the gap, an effort has been made to provide workshops and special training courses.



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Virtual space | A number of companies are already using virtual space to present and elaborate their product models. Multiple projectors are used to display the image of a part on several screens at the same time. People in the room wear special glasses that combine the different images into a three-dimensional model, just like in a 3D movie. People in the automotive industry have found a way to project an entire vehicle interior around a simulated driver's seat. The virtual interior makes it possible to see how well the different elements of the design fit together or whether the steering wheel is properly positioned. The simulation makes it easy to move any elements that don't fit.

Mechanical engineers can also use virtual space to present components or entire machines. This allows them to discuss the models with other departments.

As the technology becomes easier to use and the costs become lower, use of virtual space will continue to grow. Even so, computer-aided design software will remain crucial for the design of the part. This is because most of the work involved in designing a part is actually drawing it.

Automated design? | Computer technology has come a long way, and is still advancing every day. Nevertheless, computer software is no substitute for human creativity. Design software will remain a tool that design engineers use to make modeling easier, while enhancing the precision and efficiency of their work.

At the same time, the data interfaces between the resource management system, computer-aided design software and programming software continue to undergo optimization. The goal and essence of the design process, however, remains the same: creative, intelligent people working to find innovative solutions.

1, 2 Still in the design stage and yet incredibly real: developers discuss their designs in virtual space.

Virtual space or "cave" Complex computer and projection technology make it possible: multiple projectors are used to display the image of a part on several different screens. The people in the "cave" wear special glasses that combine the images on the various screens into a single three-dimensional image. Cameras, meanwhile, are used to monitor the position of the observer. If the observer moves, the image changes accordingly. This allows the observer to examine the part from different angles: from above, from below – even from the inside!

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