



**A COMPREHENSIVE GUIDE TO**

# **Sheet Metal Fabrication**



**Manufacturing  
Process &  
Design Guide**

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# Overview of Sheet Metal Fabrication

Sheet metal fabrication plays a crucial role in modern manufacturing, supporting industries from consumer goods to aerospace. From small components like toys to large-scale airplane structures, this process provides the versatility and precision required to meet diverse production needs. Understanding how sheet metal fabrication works is essential for appreciating its wide-ranging applications.

01



## What Is Sheet Metal Fabrication

Sheet metal fabrication refers to the process of transforming flat sheets of metal into functional parts and finished products. This is achieved through a series of operations such as cutting, folding, bending, and assembling.



A variety of metals can be used in sheet metal fabrication, including steel, aluminum, stainless steel, brass, copper, and zinc. Sheet metal thickness is typically measured in gauges, ranging from approximately 0.006 to 0.25 inches. Thicker gauges are suited for heavy-duty applications requiring strength and durability, while thinner gauges offer greater flexibility and ease of shaping.

Before production begins, fabricators go through a detailed design phase to establish product specifications. Based on these requirements, they select the most appropriate techniques to achieve the desired outcome. The core processes generally include: cutting, forming, joining, and finishing.

Together, these methods allow manufacturers to produce reliable and customizable sheet metal components for a wide range of industries.

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# Sheet Metal Fabrication Processes

02



There are multiple techniques for shaping and manipulating sheet metal, each suited to different applications. A clear understanding of these processes is essential for creating efficient designs and selecting the most appropriate methods for your projects. This section provides an overview of the key types of sheet metal fabrication.

# Sheet Metal Cutting Techniques

Cutting is one of the most fundamental processes in sheet metal fabrication. It involves separating material into desired shapes and sizes. Cutting methods can be broadly divided into two categories:

1. Cutting without shear – includes laser cutting, plasma cutting, and waterjet cutting.
2. Cutting with shear – includes shearing, blanking, punching, and sawing.

Below, we'll look at these techniques in detail, starting with laser cutting.

## Laser Cutting

Laser cutting is a thermal cutting process that uses a focused laser beam to melt or vaporize material along a precise path. The process combines two simultaneous actions:

1. A high-powered laser beam is focused onto the sheet metal surface, causing localized heating, melting, or vaporization.
2. A cutting nozzle delivers an assist gas (commonly nitrogen or oxygen) that clears molten material from the kerf, protects the optics, and improves cutting quality.



Laser cutting works effectively on a wide range of metals, including stainless steel, mild steel, and non-ferrous metals. However, highly reflective materials such as aluminum can be more challenging. In such cases, fiber lasers generally perform better than traditional CO<sub>2</sub> lasers.

Depending on laser power, sheet thicknesses of up to 20–40 mm can be cut, though optimal performance is usually achieved on thinner sheets.

### Advantages:

1. High precision and accuracy
2. Excellent edge quality with minimal finishing required
3. Flexible and efficient for both prototyping and production

### Limitations:

1. High energy and gas consumption
2. Expensive equipment and operational costs
3. Requires strict safety measures due to the laser beam and fumes

Laser cutting is widely used in industrial manufacturing, particularly where accuracy, speed, and repeatability are critical.

## Plasma Cutting

Plasma cutting is a thermal cutting process that uses a jet of ionized gas (plasma) to melt and expel material from the cut area. The plasma arc generates intense localized heat, which rapidly melts the metal, while the high-velocity gas stream blows away the molten material to form a cut.

Plasma cutting is only applicable to electrically conductive metals, such as aluminum, stainless steel, copper, brass, and mild steel. It is particularly effective for cutting medium to thick sheets (up to ~50 mm), especially when extreme surface precision is not required.

### Advantages:

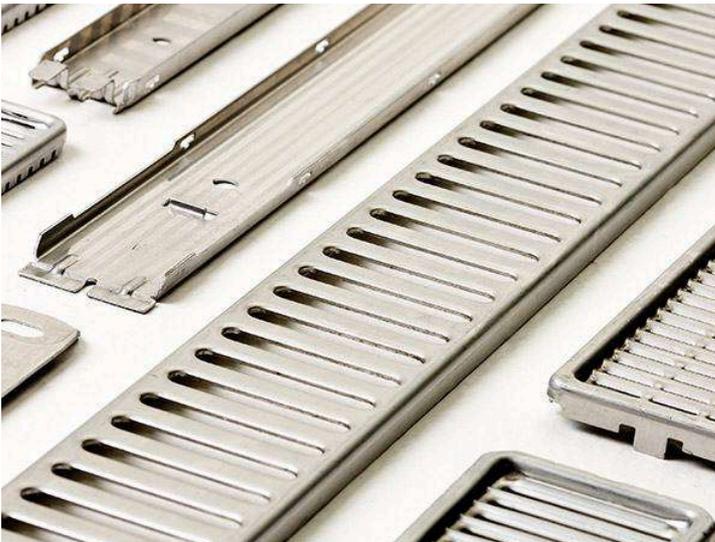
1. Faster cutting speed compared to many other methods
2. Suitable for a wide range of conductive metals
3. High repeatability and relatively easy to automate
4. Lower heat input compared to oxy-fuel cutting, reducing material distortion

### Limitations:

1. Produces a rougher cut with noticeable burrs and an oxidized heat-affected zone (HAZ)
2. Higher power consumption compared to some alternatives
3. Can generate significant noise and fumes, especially in dry cutting operations

Plasma cutting is widely used in construction, automotive repair, shipbuilding, and industrial fabrication where speed and versatility are prioritized over achieving a fine surface finish.





## Blanking

Blanking is a shearing process in which a punch and die are used to cut out a flat piece of sheet metal from a larger stock sheet. During the operation, the die holds the sheet metal securely in place, while the punch applies force to shear through the material.

In blanking, the cut-out piece (the blank) is the desired component, while the remaining sheet is considered scrap or leftover stock. Blanks produced by this method typically require little to no further finishing, making blanking a highly efficient process for mass production.

### Advantages:

1. High precision and consistency
2. Cost-effective for large-scale production runs
3. Produces components that usually require minimal secondary processing
4. Suitable for a wide range of metals and thicknesses

### Limitations:

1. Initial tooling costs for punch and die sets can be high
2. Not economical for small production runs
3. Limited to producing flat parts (no complex 3D shapes)



## Shearing

Shearing is a sheet metal cutting process that uses a straight, linear force to separate material along a straight line. The process applies a shearing force between two blades—one fixed and one moving—causing the material to fracture and separate cleanly along the cutting path.

This method is particularly effective for high-volume production and is well-suited for cutting relatively soft and thin metals such as aluminum, mild steel, and brass. Shearing is commonly used to trim sheet edges or cut sheets into smaller sections with straight edges.

### Advantages:

1. Fast and efficient for large-scale production
2. Cost-effective for high-output operations
3. Ideal for producing thousands of straight cuts in a short period
4. Minimal material waste compared to some other cutting methods

## Sawing

Sawing is a cutting process that removes material using a saw blade with multiple teeth. Each tooth progressively engages the workpiece, applying friction and shear force to separate small chips from the material until the cut is complete.

Band saws are the most common sawing tools used in sheet metal and bar stock processing. They offer several advantages, particularly when equipped with slightly offset (marginally bent) teeth, which are well-suited for cutting aluminum, brass, copper, and other non-ferrous metals.

1. Horizontal band saws are typically used to cut long bars or stock material down to specific lengths.
2. Vertical band saws are better suited for more complex tasks, such as cutting precise contours or irregular shapes in metal parts.

Modern band saws are designed with features such as dual-bearing systems, blade-tracking adjustments, and guided rollers, which enhance stability and accuracy. They are capable of producing highly accurate straight cuts with narrow kerfs, minimizing material waste and lowering overall fabrication costs.

### Advantages:

1. Accurate, straight, and contour cutting
2. Narrow kerf reduces material waste
3. Effective for both ferrous and non-ferrous metals
4. Flexible setup for different stock sizes and shapes

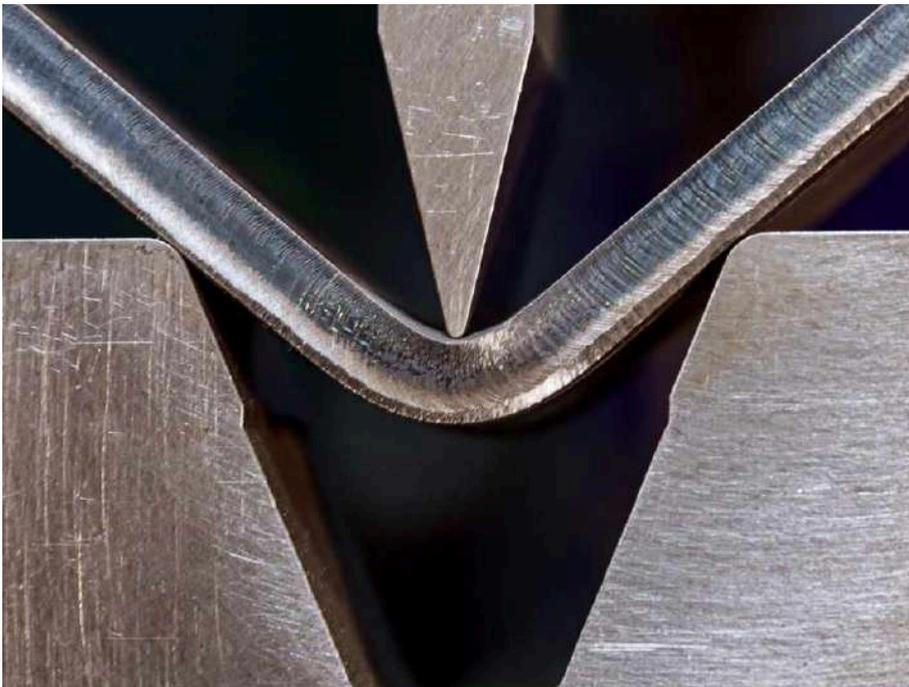
### Limitations:

1. Maintaining stable contact between flat workpieces and the blade can be challenging
2. Potential for cutting inconsistencies if the material shifts during operation
3. Slower than thermal cutting methods for large-scale production



# Sheet Metal Forming Techniques

Sheet metal forming involves reshaping metal materials while they are still in their solid states. This section will cover the most important forming processes for sheet metal. These processes are varied in their applications for making custom fabricated parts.



## Bending

Bending is a metal forming process in which force is applied to deform sheet metal and create an angle or curve to achieve the desired shape. It is commonly performed using press brakes and rolling machines. A press brake employs a punch and die to bend sheet metal precisely, while rolling machines—available in different configurations—can curve sheet metal into cylindrical or conical shapes within specific limits.

This process works best with malleable, non-brittle metals such as mild steel, spring steel, aluminum 5052, and copper. In contrast, materials like aluminum 6061, brass, bronze, and titanium are more challenging to bend due to their higher strength or lower ductility.

Bending is a cost-effective method for low- to medium-volume production, producing components with excellent mechanical integrity. However, one limitation is the tendency for springback, where the metal partially returns toward its original shape, which can affect the final bend angle.

Sheet metal bending include:

### Bending

This method bends metal sheets into curved shapes or rolls. It uses a press brake, a hydraulic press, and three rollers to create the desired bend. It is preferred for components like tubes, cones, and other hollow-shaped materials.

### Rotary bending

This method bends metals into sharp corners. It is a great choice for bending angles greater than 90 degrees.

### Wipe bending

It uses a wipe die to determine the inner radius of the sheet metal's bend.

### V-bending

Here, the bending punch supplies the force to bend metal materials (placed over the V-die) at desired angles. This method bends steel plates without changing their position.

### U-bending

His bending process is similar to v-bending. The only differences are that it uses a U-die and the final components are U-shaped.

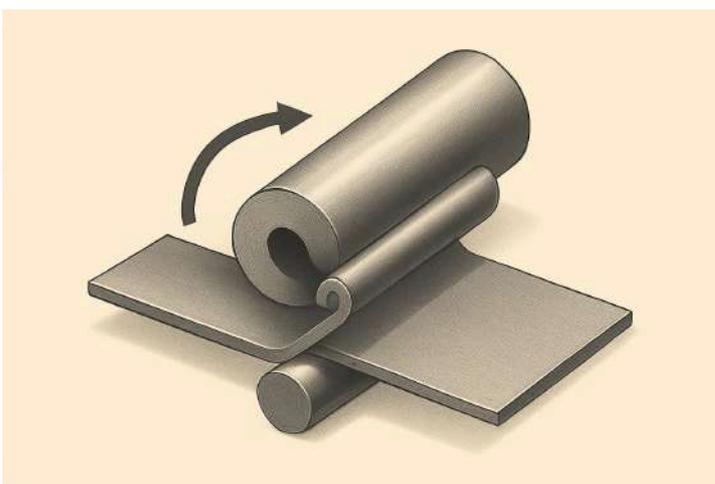
## Hemming

Hemming is a forming process in which the edge of a sheet metal part is folded back onto itself, creating a section with two layers of material. The operation is typically carried out in two stages:

1. The sheet metal is first bent and pressed into a V-die.
2. The partially formed hem is then transferred to a flattening die, where it is pressed flat to achieve the final shape.

Hemming is widely used to reinforce edges, eliminate sharp borders, and enhance the appearance of sheet metal parts. Its high level of accuracy contributes to superior surface quality and improved part aesthetics.

However, the process can also cause material deformation, which may result in dimensional variations that require careful control.



## Rolling

Sheet metal rolling is a forming process in which a metal workpiece is passed between a pair of rotating rollers to reduce its thickness or achieve uniform thickness. The rollers apply continuous compressive forces that plastically deform the material. When the rollers are set perpendicular to the sheet surface, the process results in flattening of the metal.

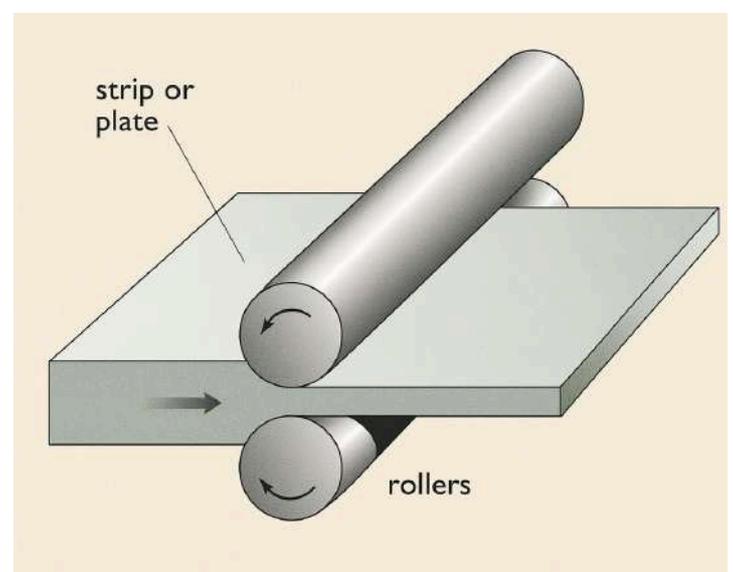
There are two main rolling methods:

1. Hot rolling: performed above the metal's recrystallization temperature, improving workability and allowing large reductions in thickness.
2. Cold rolling: carried out at or near room temperature, enhancing surface finish and dimensional accuracy.

Rolled sheet metal is widely used in the production of pipes, tubes, stampings, discs, wheels, and wheel rims, among other applications.

### Advantages:

1. High-speed process suitable for large-scale production
2. Can achieve tight tolerances and uniform properties
3. Capable of forming complex cross-sectional profiles



## Curling

Sheet metal curling is the process of adding circular, hollow rolls to sheet metal edges. Most curling processes occur in three stages; the first two stages create the curves for the curl, while the third stage closes up the curl.

Curls help to remove sharp, untreated edges from a workpiece to make it safer for handling. A curled edge also provides strength to the edge. Curling can also lead to burrs and material deformations, so care must be taken during the process.



## Metal Spinning

Metal spinning is a forming process used to shape flat metal discs into rotationally symmetrical hollow parts. In this process, the disc is positioned between the tailstock of the spinning machine and a shaped mandrel. As the workpiece rotates, a spinning roller gradually presses the metal against the mandrel, forming it into the desired shape.

This technique is suitable for ductile metals such as stainless steel, copper, brass, and aluminum. It allows the production of hollow components in various shapes without compromising material strength or surface quality.

One advantage of metal spinning is its flexibility. It can be integrated with other sheet metal forming operations, such as bending or punching, within the same cycle, making it efficient for both small batches and large-scale production.

However, the process is limited in terms of geometry. Metal spinning can only produce concentric, axisymmetric parts, restricting its use for more complex or asymmetrical designs.

# Sheet Metal Welding Techniques

## Metal Inert Gas (MIG) Welding

Also known as Gas Metal Arc Welding (GMAW), MIG welding uses a continuous wire electrode combined with a shielding gas. The wire electrode melts during the process, filling the joint and fusing the metal parts, while the shielding gas protects the weld pool from atmospheric contamination. MIG welding produces high-quality welds at excellent speeds and can be fully automated, which reduces spatter and improves consistency. However, it is less suitable for very thick materials or outdoor applications, as wind can disrupt the shielding gas.

## Stick Welding or Shielded Metal Arc Welding (SMAW)

Stick welding employs a consumable electrode coated in flux, which creates an arc when it touches the base metal. The electric arc generates temperatures exceeding 6,300°F (≈3,480°C), melting both the electrode and the workpiece to form the weld.

This method is versatile, working with both AC and DC power sources, and is suitable for construction, repair, and heavy-duty applications. However, it requires caution when welding thin sheet metals, as the intense heat may burn through or distort the material.

Welding is a process used to join two or more sheet metal pieces by applying heat, pressure, or a combination of both. The process typically involves melting the base metal and, in many cases, adding a filler material to strengthen the joint.

In sheet metal fabrication, several welding methods are employed to create strong and durable connections. These techniques rely on controlled melting and fusion of the metal, with or without filler addition. Common welding techniques for sheet metal include:

## Tungsten Inert Gas (TIG) Welding

TIG welding uses a non-consumable tungsten electrode to generate a stable arc. An inert shielding gas, typically argon, protects both the weld pool and the electrode from atmospheric contamination. Filler material may be added separately when required.

This technique provides a high level of control, producing clean, strong, and precise welds. It is particularly effective for non-ferrous metals such as aluminum, copper, and titanium, making it popular in the automotive and aerospace industries.

The main limitation is that TIG welding is more time-intensive and requires a skilled operator due to its complexity.

# Sheet Metal Riveting

Riveting is a non-thermal, semi-permanent joining method that connects sheet metal parts using rivets or other mechanical fasteners. The process begins by drilling a hole in the sheets to be joined, followed by inserting the rivet. Once in place, the rivet's tail is deformed by hammering or pressing, flattening it to lock the sheets together and prevent removal.

Riveting can be performed in two ways:

1. Hot riveting – used mainly for steel rivets with diameters greater than 10 mm, heated to about 1000–1100°C before installation. The process typically applies a hammering pressure of 650–800 MPa.
2. Cold riveting – better suited for non-ferrous and light metals such as aluminum or copper, typically with rivet diameters under 10 mm.

This method is widely applied to non-ferrous sheet metal components (e.g., copper and aluminum). Riveting is valued for being efficient, cost-effective, and reliable, while also allowing straightforward quality inspection of joints.

However, rivets have certain limitations: rivets can add extra weight, and the required holes weaken the sheet metal. In addition, riveted joints may produce noise and vibration during operation.



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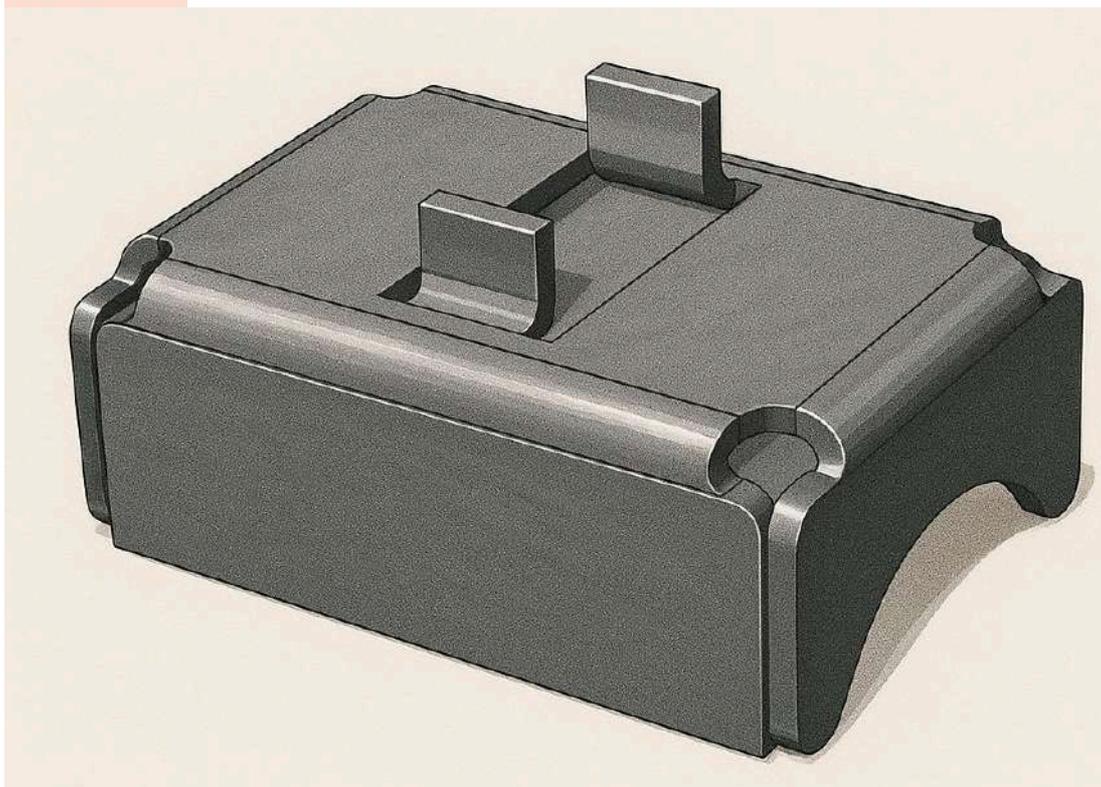
# Sheet Metal Fabrication Tolerance

Sheet metal fabrication tolerances define the allowable deviations in size and geometry of parts to ensure accurate assembly, reliable performance, and consistent integration.

These standards cover key tolerances, including: linear dimensions, angular dimensions, flatness and straightness, cylindricity, and circularity.

For sheet metal components, ISO 2768 standards are commonly applied to control both dimensional and geometrical tolerances. For example, ISO 2768-mK specifies medium precision for linear dimensions (m) and general tolerance class for geometrical features (K).

03



## Metal Spinning

Permissible deviations in mm for ranges in nominal lengths	Tolerance Class Designation (Description)			
	f (fine)	m (medium)	c (coarse)	v (very coarse)
0.5 up to 3	0.5 Up To 3	±0.1	±0.2	-
over 3 up to 6	±0.05	±0.1	±0.3	±0.5
over 30 up to 120	±0.1	±0.2	±0.5	±1.0
over 120 up to 400	±0.15	±0.3	±0.8	±1.5
over 400 up to 1000	±0.2	±0.5	±1.2	±2.5
over 1000 up to 2000	±0.3	±0.8	±2.0	±4.0
over 2000 up to 4000	±0.5	±1.2	±3.0	±6.0

## External Radius and Chamfer Heights

Permissible deviations in mm for ranges in nominal lengths	Tolerance Class Designation (Description)			
	f (fine)	m (medium)	c (coarse)	v (very coarse)
0.5 up to 3	±0.2	±0.2	±0.4	±0.4
over 3 up to 6	±0.5	±0.5	±1.0	±1.0
over 6	±1.0	±1.0	±2.0	±2.0

## Angular Dimensions

Permissible deviations in mm for ranges in nominal lengths	Tolerance Class Designation (Description)			
	f (fine)	m (medium)	c (coarse)	v (very coarse)
Up to 10	$\pm 1^\circ$	$\pm 1^\circ$	$\pm 1^\circ 30'$	$\pm 3^\circ$
over 3 up to 6	$\pm 0^\circ 30'$	$\pm 0^\circ 30'$	$\pm 1^\circ$	$\pm 2^\circ$
over 30 up to 120	$0^\circ 20'$	$0^\circ 20'$	$\pm 0^\circ 30'$	$\pm 1.0$
over 120 up to 400	$\pm 0^\circ 10'$	$\pm 0^\circ 10'$	$\pm 0^\circ 15'$	$\pm 0^\circ 30'$
over 400 up to 1000	$\pm 0^\circ 5'$	$\pm 0^\circ 5'$	$\pm 0^\circ 10'$	$\pm 0^\circ 20'$

04



## Design Tips for Sheet Metal Fabrication

The following design tips provide practical guidance for creating efficient and cost-effective sheet metal parts. They are derived from established Design for Manufacturing (DFM) principles, evolving industry requirements, and insights gained from analyzing fabricated metal products.

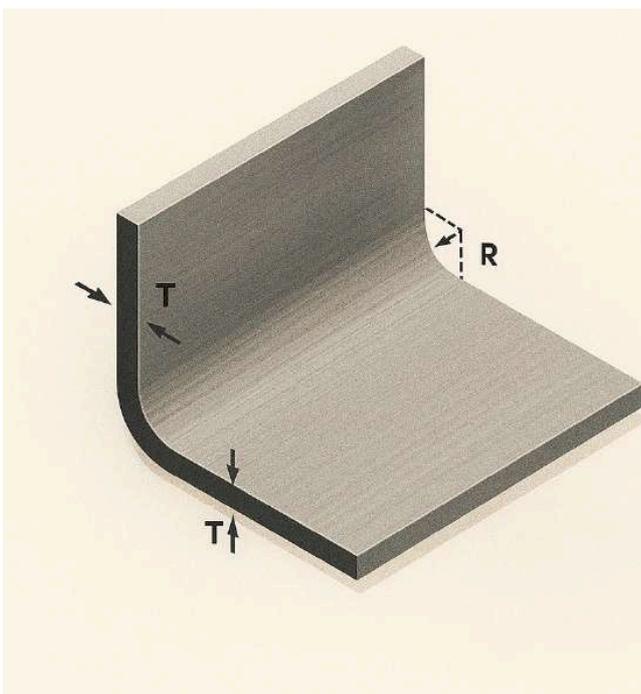
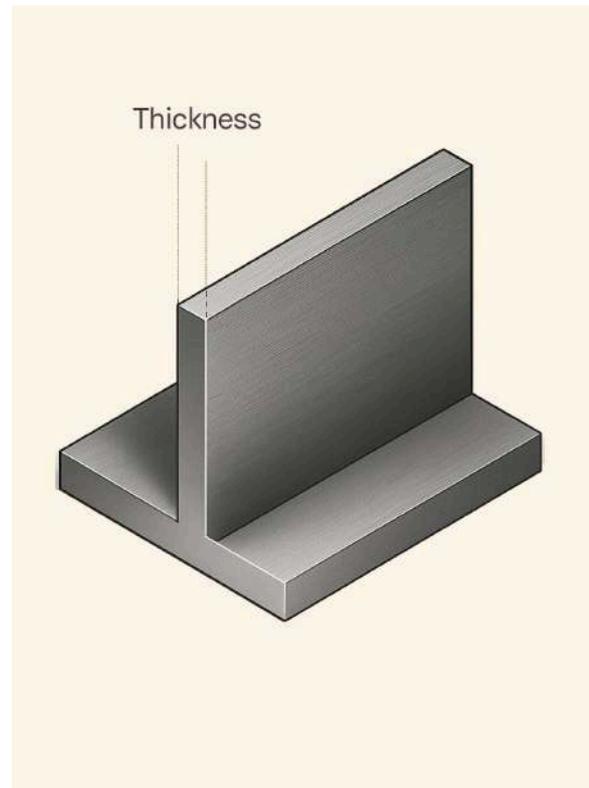
## Bends

Bends in sheet metal fabrication are defined by several critical parameters, which must be consistent with the selected tooling to ensure accurate and defect-free results.

### K-Factor

The K-factor represents the location of the neutral axis during bending, expressed as the ratio between the distance from the inside surface to the neutral axis ( $t$ ) and the total material thickness ( $Mt$ ):

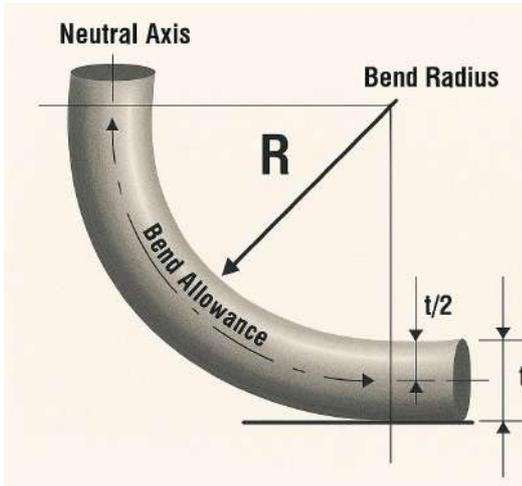
$$\text{K-factor} = t : Mt$$



## Wall Thickness

Maintaining uniform wall thickness across the part is critical for structural integrity and manufacturability.

1. Sheet metal is generally defined as materials less than 3 mm thick.
2. For laser cutting, typical sheet thickness ranges from 0.5 mm to 10 mm.
3. For bending operations, practical thickness is usually between 0.5 mm and 6 mm, depending on the material and equipment.

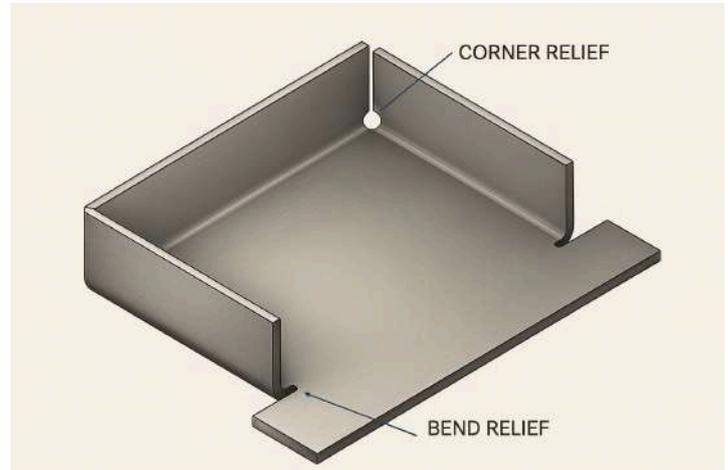


## Bend Radius

The bend radius is defined as the distance between the bend axis (neutral line) and the inner surface of the material. A smaller bend radius increases the strain on the workpiece, potentially leading to tearing or deformation.

When designing bends in the same plane, it is recommended that they all bend in the same direction. This approach minimizes the need for part re-orientation during fabrication and simplifies the bending process.

For ductile materials such as stainless steel, the inner bend radius should generally be at least equal to the material thickness. For more brittle metals, larger bend radii are preferred to reduce the risk of cracking or distortion around the bend.



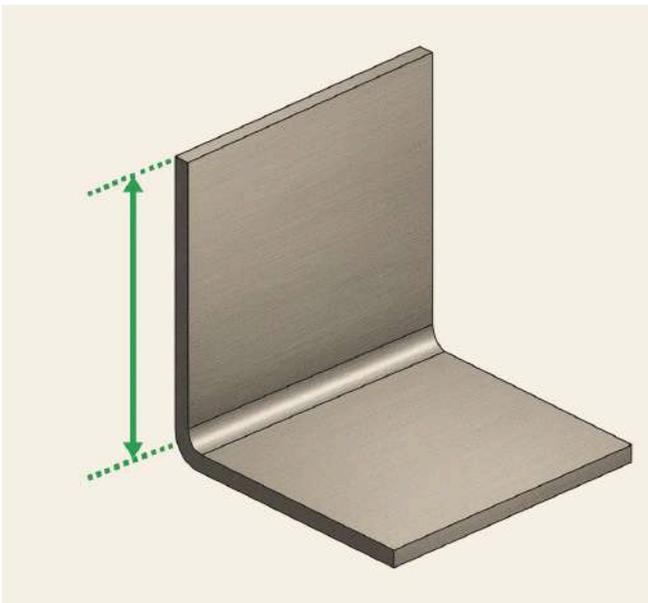
## Bend Relief

When bends are located close to the edge of a sheet metal part, the risk of tearing and deformation increases. Incorporating bend reliefs into the design helps prevent cracks and splitting during bending and can also reduce springback in the bend area.

The depth of a bend relief should generally be at least equal to the bend radius, while the width should be at least equal to the material thickness. Properly sized bend reliefs improve the manufacturability of the part and help maintain dimensional accuracy.

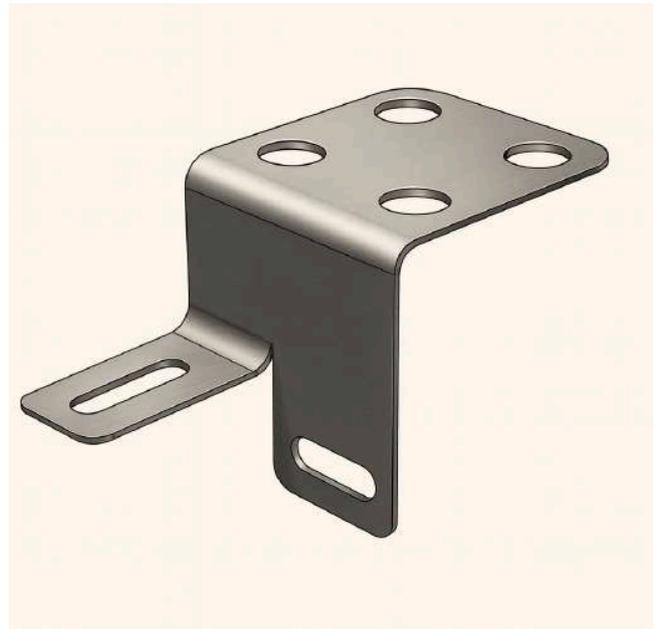
## Bend Height

Bend height is generally recommended to be at least two times the material thickness plus the bend radius. If the bend height is too small, the material may be difficult to clamp and position properly in press brakes, leading to insufficient support during forming. This often results in poor bend accuracy, deformation, or even part failure.



## Bend Orientation

Maintaining a consistent bend orientation across a sheet metal part is important for efficient fabrication. Consistent orientation minimizes the need to reorient the component during bending operations, which in turn reduces manufacturing time, lowers production costs, and improves overall process efficiency.

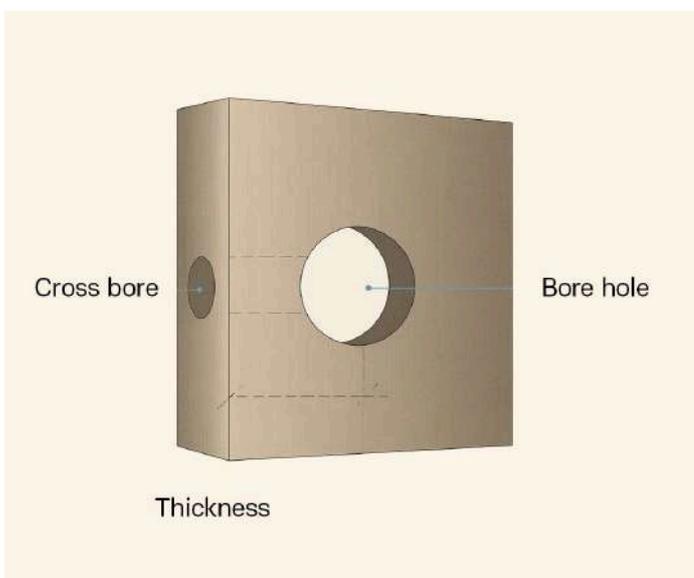


## Hole Size

In sheet metal design, the minimum hole diameter should be at least equal to the material thickness ( $D \geq T$ ). For better manufacturability and to reduce the risk of tooling damage, it is often recommended that hole diameters be slightly larger than the sheet thickness. This improves tool life, lowers production costs, and reduces processing time.

### Hole Spacing and Edge Distance

1. The center-to-center spacing between holes should be at least  $2 \times$  the sheet thickness. Placing holes too close together increases the risk of breakage or deformation during bending and forming.
2. Holes should also be kept at a sufficient distance from edges. A good guideline is to place holes at least  $1.5 \times$  to  $2 \times$  the sheet thickness away from the edge to prevent tearing and maintain part strength.

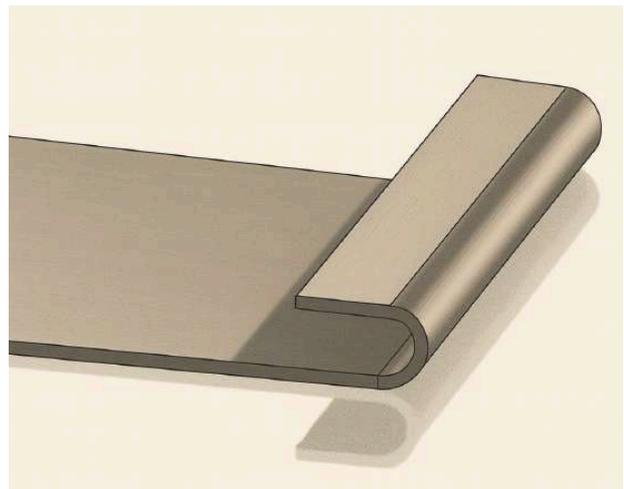


## Hems

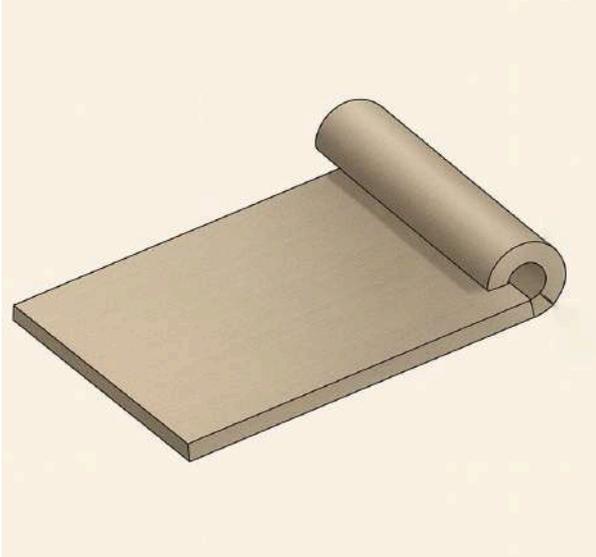
A hem is created by folding the edge of a sheet metal part back onto itself. This process is often used to eliminate sharp edges, improve safety, increase part strength, and enhance appearance.

There are different types of hems, such as open hems and closed hems, each serving different functional and aesthetic purposes.

When designing hems, it is important to allow for sufficient material length, typically at least four times the material thickness, to ensure proper forming and to avoid cracking.



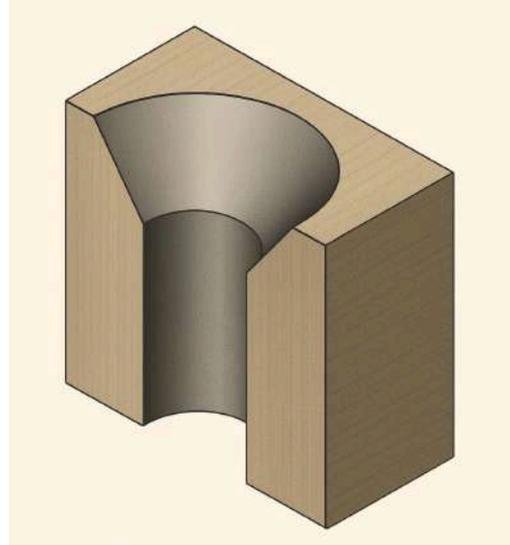
## Curls



The outside radius of a curl should be at least  $2 \times$  the material thickness. Curling involves rolling the sheet edge into a smooth, rounded shape, which increases part strength and improves safety during handling.

When placing holes near curled edges, the minimum distance from the hole center to the curl edge should be at least the curl radius plus the material thickness to avoid weakening the structure.

## Countersinks



The depth of a countersink should not exceed  $0.6 \times$  the material thickness.

The center-to-center distance between countersinks should be at least  $8 \times$  the material thickness.

The distance from the countersink center to a bend line should be at least  $3 \times$  the material thickness.

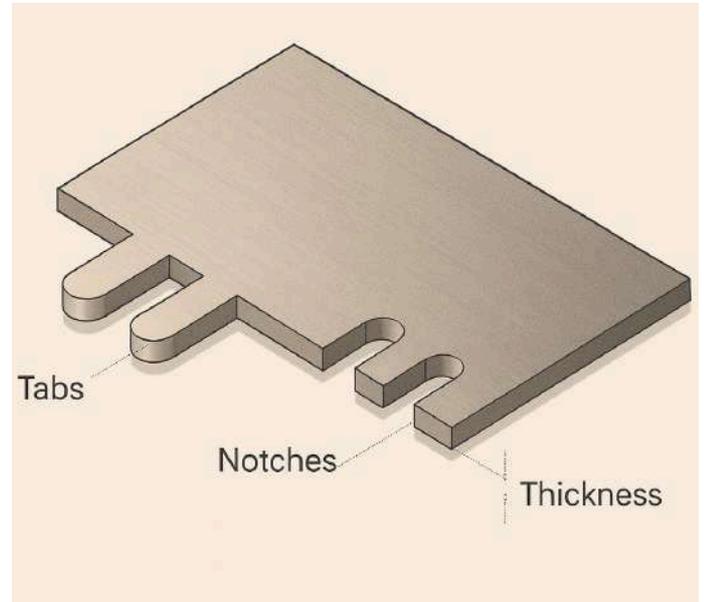
Proper design of curls and countersinks ensures structural integrity, manufacturability, and part safety.

## Sheet Metal Gauge

Sheet metal gauge is a critical design consideration in sheet metal fabrication. The material thickness should be chosen based on the part geometry and its intended application.

Using sheetmetal that is too thick can limit the achievable bend angles on press brakes. Sharp bends in thick materials are often difficult to form and may cause microscopic cracks, potentially

Unless the design specifically requires thicker material for strength or durability, it is generally better to select thinner, more pliable metals, which are easier to bend and form while reducing the risk of defects.



## Tabs and Notches

### Tabs

1. The length of a tab should not exceed  $5 \times$  its width.
2. The width of a tab should be at least  $2 \times$  the material thickness.

### Notches

1. The width of a notch should be at least equal to the material thickness.
2. Notches should be spaced at least 3 mm ( $\approx 1/8$  inch) apart.

### Placement Near Bends

If tabs or notches are located near a bend, they should be kept at a distance of at least  $3 \times$  material thickness plus the bend radius from the bend. This helps reduce warpage and deformation during forming.



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# Materials for Sheet Metal Fabrication



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A wide range of materials is available for sheet metal fabrication, making material selection a critical decision. Choosing the right material involves considering both the metal type and its physical properties. Each material has distinct characteristics and advantages, so the intended application and desired performance of the final product should guide the selection of the appropriate sheet metal.

## Stainless Steel

Stainless steel is a group of sheet metal alloys that contain at least 10.5% chromium. The chromium forms a thin, protective oxide layer on the surface, giving stainless steel significantly higher corrosion resistance compared to other steels.

In addition, stainless steel offers high strength, durability, temperature resistance, and good formability, making it widely used in sheet metal fabrication. Certain grades are also chosen for decorative or non-structural applications, such as architectural finishes and aesthetic components.

## Hot Rolled Steel

Hot rolled steel is commonly used in sheet metal fabrication when tight dimensional tolerances and smooth surface finishes are not critical requirements. Produced at high temperatures, it offers good malleability and workability, making it suitable for applications that require forming or welding.

Its strength and cost-effectiveness also make hot rolled steel a popular choice for structural components, such as beams, frames, and heavy-duty parts.

## Cold Rolled Steel

Cold rolled steel is typically about 20% stronger than hot rolled steel, thanks to the strain hardening that occurs during the cold rolling process. Its increased strength makes it suitable for applications requiring high precision and consistent material quality.

In addition, cold rolled steel has a smooth, refined surface finish, which makes it an excellent choice for aesthetic or exposed components, as well as products that require further coating or painting.

**Stainless steel is an ideal option for:**

[Cooking utensils](#)

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[Aerospace and automotive parts](#)

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[Food processing equipment and appliances](#)

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[Chemical and fuel containers](#)

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[Construction products](#)

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**Stainless steel is an ideal option for:**

[Vehicle frames](#)

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[Agricultural equipment](#)

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[Piping, tubes, water heaters](#)

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[Rail tracks and car components](#)

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**The most common applications of this steel type are:**

[Automotive parts](#)

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[Home appliances](#)

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[Metal furniture](#)

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[Lighting fixtures](#)

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[Water heaters](#)

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[Construction products](#)

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## Copper/Brass

Copper is a highly malleable and ductile material, making it easy to bend, roll, or hammer into different shapes without breaking. It also offers excellent electrical and thermal conductivity as well as strong corrosion resistance, making it suitable for electrical components, roofing, and parts exposed to corrosive environments.

Brass is an alloy of copper and zinc that combines good corrosion resistance, machinability, and aesthetic appeal. It is widely used in decorative applications, plumbing fittings, musical instruments, and some electrical components. While its electrical conductivity is lower than pure copper, brass provides good durability and formability, making it a versatile material in sheet metal fabrication.

## Pre-Plated Steel

Pre-plated steel is sheet steel with a pre-applied coating (e.g., zinc, tin, or nickel) that enhances both corrosion resistance and appearance, thereby reducing the need for additional finishing.

It is widely used in electrical enclosures, automotive parts, and consumer products where durability and surface quality matter. Careful handling is required during fabrication to prevent coating damage and loss of protection.

## Aluminum

Aluminum is a lightweight metal widely used in sheet metal fabrication, often alloyed with elements such as copper, magnesium, or manganese to improve its properties. However, not all aluminum alloys are equally suitable for fabrication. Among the most common choices are Aluminum 5052, known for its excellent corrosion resistance and formability, and Aluminum 6061, valued for its strength and weldability.

With its high strength-to-weight ratio, corrosion resistance, and good machinability, aluminum is an ideal material for applications where lightweight performance and durability are critical.

**Copper and brass give desirable, aesthetically pleasing products, and they are useful in:**

Fixtures

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Electronic equipment

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Kitchen utensils

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Chemical and fuel containers

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Bolts, nuts, and pipes

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**Stainless steel is an ideal option for:**

Vehicle frames

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Agricultural equipment

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Piping, tubes, water heaters

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Rail tracks and car components

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**Aluminum is also an excellent conductor of heat and electricity, making it a top choice for various applications like:**

Automotive and aircraft parts

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Food packaging

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Electrical and electronic products

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Kitchenware

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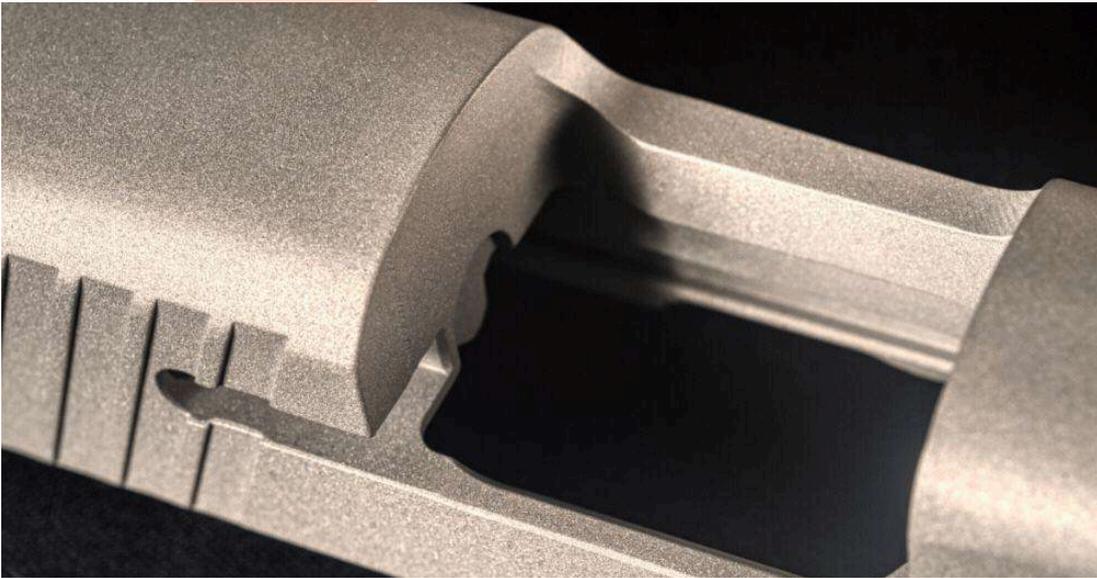
Enclosures

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Medical equipment

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06



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## Surface Finishing Options for Sheet Metal Fabrication

Applying surface finishes to sheet metal parts can enhance their durability, appearance, and performance. To select the most suitable finishing method, it is important to understand the available options. Below are some of the most common surface finishes used in sheet metal fabrication:

## Bead Blasting

Bead blasting is a surface finishing process that propels fine abrasive particles, such as sand or glass beads, onto a sheet metal surface using compressed air. The impact creates a uniform matte texture that improves the component's appearance and prepares it for further finishing, such as painting or coating.

This process works well for materials such as steel, aluminum, and copper, delivering a consistent finish without altering their dimensions. It can also enhance durability indirectly by improving the adhesion of protective coatings.

### Pros:

Safe and compatible with various sheet metal materials

Environmentally friendly

Offer a long-lasting effect

Ideal for sensitive surfaces

The abrasives used are non-reactive

### Cons:

Not a fast finish method

Not economical for smaller projects

Need for high precautionary measures during application



## Powder coating

Powder coating is a surface finishing process in which powdered paint is sprayed onto the sheet metal and then baked, forming a hard, durable layer that improves wear and corrosion resistance.

While many metals can be powder coated, stainless steel and aluminum are particularly suitable due to their good electrostatic properties and high-temperature tolerance, which ensure effective adhesion and curing of the coating.

This process is suitable for sheet metal parts because it delivers long-lasting, protective finishes with excellent chemical and heat resistance, helping components withstand extreme weather and corrosion.

### Pros:

Durable finish

Corrosion resistance

Aesthetic versatility

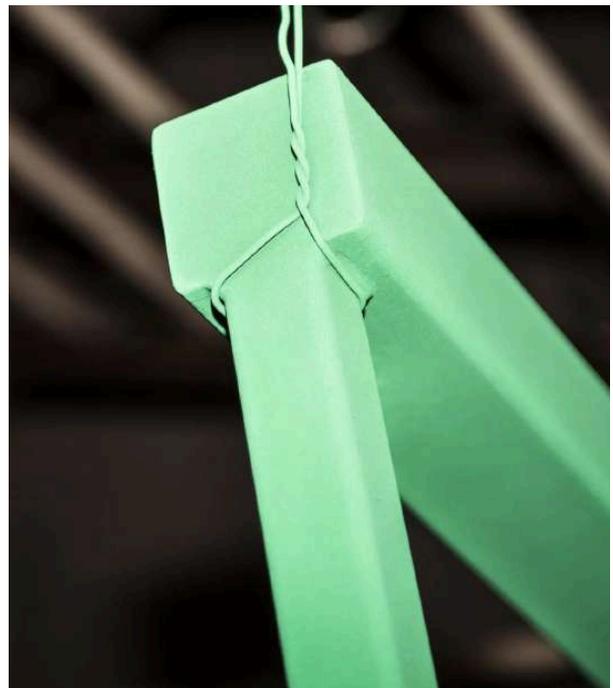
Environmentally friendly

### Cons:

Temperature limitations

Thickness control

Repair difficulty



## Anodizing



### Type I

Creates a thin protective layer on the metal surface using chromic acid. Provides moderate corrosion resistance and is mainly used for applications requiring minimal dimensional change.

### Type II

Uses sulfuric acid to produce a strong, corrosion-resistant layer. Commonly applied in decorative or functional components that require improved surface durability.

### Type III

Produces a thicker, hard surface layer with excellent wear and corrosion resistance. Often used for mechanical components, aerospace parts, and precision instruments where durability is critical.

### Applications

Anodizing is widely used in the automotive, aerospace, and mechanical industries. This finishing process provides both aesthetic appeal and enhanced corrosion resistance for sheet metal parts.

#### Pros:

Excellent abrasion and corrosion resistance

Produces irremovable metal finish

No risk of fading, chalking, or adhesion failure

The end product of anodizing is UV stable

#### Cons:

Compatible with lesser metal materials

Difficult to replicate finish on different metal parts

## Brushing

Brushing is a surface finishing process that uses filamentary brushes to improve the surface quality of sheet metal parts. It effectively removes burrs generated during fabrication without causing secondary defects.

Brushing is also suitable for cleaning weld slag, paint, rust, and dirt from metal surfaces. Using the appropriate brush can help create well-rounded corners where two surfaces meet, while maintaining dimensional tolerances.

### Pros:

- Deburring
- Surface smoothing
- Edge rounding
- Versatility
- Maintains tolerances

### Cons:

- Time-consuming
- Limited depth effects
- Tool wear

## Laser Engraving

Laser engraving is a non-contact surface finishing process that uses a focused laser beam to etch patterns, text, or designs onto sheet metal surfaces. It allows for highly precise and intricate designs without mechanically touching the material, avoiding deformation or burrs.

Common applications include branding, part identification, decorative finishes, and serial numbering on metals like stainless steel, aluminum, brass, and copper.

### Pros:

High precision

Non-contact process

Increased corrosion resistance

Permanent marking

Fast and repeatable

Minimal post-processing

### Cons:

Material limitations

High initial cost

Surface depth limitations



## Screen Printing



Screen printing, also known as silk-screening, uses a fine mesh screen and a squeegee to transfer ink onto specific areas of a sheet metal component. Stencils block areas where ink should not be applied, ensuring precise designs are produced.

This method is simple, cost-effective, and versatile, making it a popular alternative to engraving or painting. Screen printing can accommodate a wide range of colors and sizes and is ideal for company logos, part labels, nameplates, and safety instructions on sheet metal parts.

### Pros:

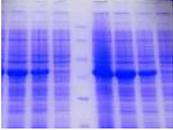
Suitable for a wide range of sheet metal

Long-lasting printing and protection with the right adhesives

### Cons:

Precision color matching is challenging

Finish	Description	Applications	Pros	Cons	Price
Passivation 	The Sheet Metal Material Is Immersed In An Acid Bath Of Citric Or Nitric Acid. The Acid Dissolves The Iron But Leaves The Chromium To Form A Thick, Protective Chromium Oxide Layer.	It Is Used Mainly To Prevent Corrosion On Stainless Steel Materials By Creating A Protective Oxide Layer That Won't React With The Environment.	A. It Prevents Chemical Degradation Of The Material  B. Impacts Corrosion Resistance On The Sheet Metal Part	Not Give A Smooth Surface On The Metal. It Requires Pre-Cleaning.	+\$\$\$
Electroplating 	It Involves The Bonding Of Fine Metal Layers On Another Metal Surface To Create An Electrolytic Cell. A Thin Metallic Coating Forms On The Surface Of The Substrate After The Process.	It Can Have Functional And Aesthetic Purposes On The Metal And Also Enhances The Product's Corrosion Resistance.	A. Creates A Protective Barrier On The Substrate  B. Reduces Friction Between Moving Parts  C. Improves Adhesion Properties To Paints  D. Adds A Thin, Functional Coating Layer Without Altering The Overall Material Thickness.	A. Be Relatively Expensive  B. Requires The Operator To Take Extra Precautionary Measures	+\$\$\$
Electropolishing 	This Electrochemical Finishing Process Removes Thin Layers Of Material From The Metal Part To Leave A Smooth, Shiny, And Clean Surface.	It Removes Parts Of The Material To Improve The Surface Roughness Of The Finished Component.	A. Increases Corrosion Resistance  B. Reduces Product Adhesion  C. Increases Ease Of Cleaning  D. Aesthetic Advantages	A. Limited Process Runtime  B. Removes Only A Limited Amount Of Material (Not Suitable For Heavy Stock Removal).	+\$\$\$

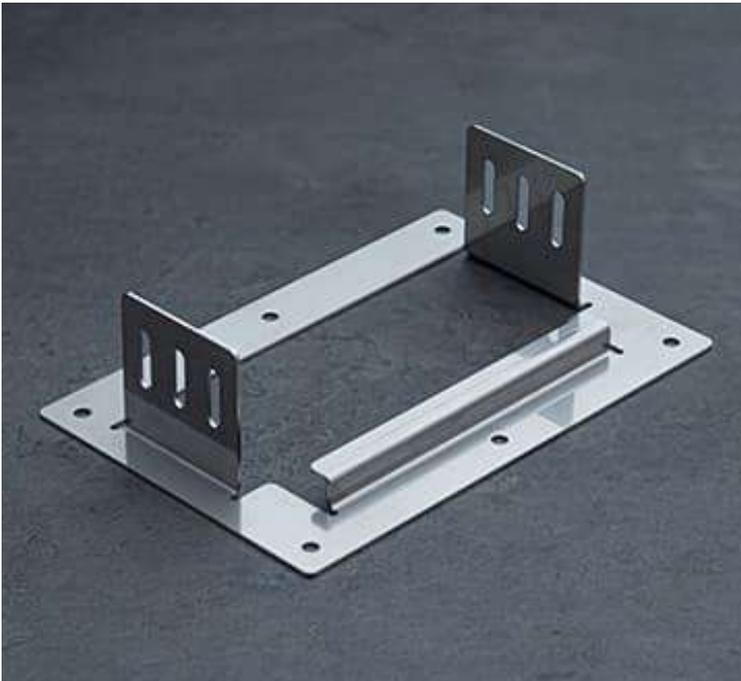
Finish	Description	Applications	Pros	Cons	Price
Painting 	This Finish Involves Spraying Layers Of Paint On The Part's Surface. It Adds Colored Layers To The Metal Surface To Offer Protective Advantages. The Traditional Wet Painting Process Sprays Water- Or Solvent-Based Paints On The Machined Parts.	Painting Improves The Appearance Of The Product And May Provide A Means Of Brand Recognition To Consumers. It Also Has Protective Effects On Sheet Metal Parts	A. Achieves A Custom Color On Several Materials  B. It Offers A Great Level Of Finishing Control  C. Can Help Conceal Manufacturing Defects  D. Provides A Smooth Surface  E. It Is Cost-Effective	A. It May Not Be As Durable As Other Surface Finishes  B. It May Require Several Applications To Reach The Desired Color And Thickness	+\$\$\$
Electrophoresis 	It Involves Immersing The Metal Substrate In A Liquid Bath Containing Charged Paint Particles, Which Are Deposited Onto The Surface Under An Applied Voltage.	It Enhances Corrosion Resistance, Surface Uniformity, And Coverage Of Complex Shapes.	A. Long-Lasting, Bright Finish With High Durability  B. Increased Hardness, Corrosion Resistance, And Impact Performance  C. Good Impact Resistance	A. Higher Equipment And Process Costs  B. Difficult Porosity Control	+\$\$\$

Finish	Description	Applications	Pros	Cons	Price
<p data-bbox="52 365 220 394">Laser Etching</p> 	<p data-bbox="288 327 555 674">Laser Etching Creates Marks By Locally Heating The Surface, Causing It To Melt Slightly And Expand, Resulting In Visible Color Or Texture Changes. The Etching Can Come In Black, Gray, Or White.</p>	<p data-bbox="560 327 821 517">It Helps To Create Permanent Markings On Sheet Metal Products For Brand Identity Or Proper Identification.</p>	<p data-bbox="826 327 1091 775">                     A. Versatile Process Suitable For Many Metals                       B. Durable, Heat-And Wear-Resistant Markings                       C. Faster Than Laser Engraving Since Less Material Is Altered                 </p>	<p data-bbox="1096 327 1361 707">                     A. Equipment Cost Is Relatively High                       B. Less Depth And Durability Compared To Engraving                       C. Generates Hazardous Fumes, Requiring Proper Ventilation                 </p>	<p data-bbox="1430 327 1485 356">+\$\$\$</p>

07

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## Applications of Sheet Metal Fabricated Parts



Sheet metal fabricated parts are widely used across industries due to their strength, versatility, and cost-effectiveness. Understanding their applications helps highlight the functional roles these components play in different sectors and provides insight into the industries that rely on sheet metal solutions.



## Aerospace

Components in the aerospace industry demand high precision, tight tolerances, and lightweight construction. Sheet metal fabrication enables the production of complex, space-ready parts using materials such as aluminum and steel. Key applications include:

**Aircraft and spacecraft structures:** Lightweight panels, airframes, and contoured aerodynamic surfaces.

**Aerodynamic components:** Airfoils and smooth, large-scale parts for improved airflow.

**Custom interface panels and fasteners:** Cost-effective fabrication of specialized connectors and hardware.

**Assembly tooling and fixtures:** Supports for precise assembly processes.

**Enclosures and housings:** Sensor enclosures, avionics casings, and protective covers.

Sheet metal fabrication provides versatility, precision, and cost-effectiveness, making it ideal for a wide range of aerospace components.

## Healthcare

The healthcare industry demands materials and components that meet strict standards for precision, durability, and sterilization. Sheet metal fabrication is particularly well-suited to meet these needs, providing accuracy, consistency, and flexibility. Key applications include:

**Surgical instruments:** Scalpels, forceps, and other high-precision tools manufactured with tight tolerances.

**Medical device enclosures:** Housings for MRI-compatible devices, diagnostic equipment, and monitoring systems.

**Custom medical instruments:** Specially designed tools and components tailored for specific procedures or functions.

**Sterilizable components:** Stainless steel and aluminum parts that can withstand repeated cleaning and sterilization.

**MRI and imaging applications:** Aluminum and non-magnetic stainless steel components suitable for environments sensitive to magnetic fields.

Automated sheet metal fabrication reduces human error, ensures high precision, and allows rapid prototyping or modification, making it ideal for the highly regulated healthcare sector.



## Appliances

Sheet metal fabrication plays a central role in the appliance industry, enabling the production of durable, precise, and cost-effective components. Its versatility allows manufacturers to meet strict specifications while designing both structural and functional parts. Key applications include:

**Appliance enclosures:** Housings for blenders, mixers, refrigerators, and other kitchen appliances.

**Internal components:** Frames, brackets, and support structures that maintain alignment and functionality.

**Dispensing and fluid handling parts:** Capillary tubes, pumps, and valves used in appliances.

**Custom or specialized parts:** Components tailored for unique appliance designs or enhanced durability.

**Control and interface panels:** Sheet metal panels for switches, displays, and user interfaces.

The wide availability of sheet metal materials and advanced fabrication techniques ensures high-quality, reliable products for the appliance sector.



## Electronics

Sheet metal fabrication is integral to the electronics industry, providing precise, durable, and cost-effective components for a wide range of devices. Advanced fabrication techniques enable rapid prototyping and mass production while maintaining tight tolerances. Key applications include:

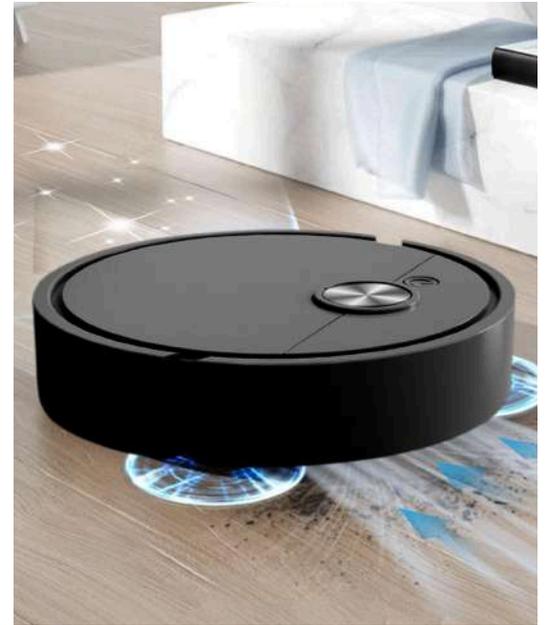
**Enclosures and casings:** Housings for computers, cell phones, tablets, LED lighting, and audiovisual equipment.

**Structural frames and supports:** Internal brackets, chassis, and mounting structures for electronic components.

**Heat management components:** Heat sinks, vents, and panels that assist in thermal regulation.

**Telecommunications and drone components:** Frames, mounts, and protective casings for antennas, drones, and networking equipment.

**Custom prototypes and specialized parts:** Rapid prototyping using laser cutting, waterjet cutting, CNC punching, and press brakes to accelerate design iterations.





## Enclosures

Sheet metal fabrication is essential for creating enclosures that protect and organize electronic and mechanical components. Its precision, durability, and versatility make it ideal for producing housings that safeguard sensitive equipment. Key applications include:

**Protective housings:** Enclosures for electronic devices, control panels, and gearboxes to shield components from dust, moisture, and mechanical damage.

**Access and interface openings:** Cutouts for cable connections, LED panels, HDMI ports, light pipes, and glass windows.

**Structural supports:** Internal frames and mounting brackets within enclosures to secure components in place.

**Custom or specialized enclosures:** Tailored designs for unique devices or industrial machinery requiring specific dimensions or access points.

Sheet metal fabrication provides a cost-effective and precise solution for producing enclosures that meet both functional and environmental protection requirements.

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# Advantages and Disadvantages of Sheet Metal Fabrication Parts

Sheet metal fabrication encompasses a variety of techniques and processes, each with its own strengths and limitations. The following section summarizes the key advantages and disadvantages of manufacturing parts using sheet metal fabrication.

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# Advantages

## Efficiency and Accuracy

Sheet metal fabrication is highly effective for producing electronic enclosures and protective housings for sensitive equipment, such as gearboxes and control panels. Fabricated parts shield components from environmental factors like dust and debris, while precise cutouts can be created for interfaces including LED panels, HDMI ports, light pipes, and glass windows.

Many sheet metal processes are now automated using CNC machines, laser cutters, and turret punches. Once programmed, these machines can produce components with high precision and consistency, minimizing human error. While minor defects may still occur, automation significantly improves accuracy and repeatability compared to manual methods.

## A Wide Range of Techniques and Materials

There are several techniques used to bring a sheet metal fabricated part to life. These techniques include cutting, bending, punching, stamping, rolling, etc. Each of the processes has its distinct purpose for creating different shapes and sizes of components. There are also many surface finishing options to choose from whenever a component requires additional finishing.

Similarly, you can choose from a wide range of sheet metal materials, including stainless steel, aluminum, copper, steel, and other custom metals. Your choice of material will depend on the final application of your product.

## Manufacture Lightweight Parts

Advances in sheet metal fabrication have significantly improved the speed, efficiency, and precision of producing both prototypes and production components. High-precision processes, such as laser cutting, allow thin metal sheets to be cut rapidly while maintaining tight tolerances. For example, high-power lasers can cut 1 mm steel sheets at speeds approaching 18 m/min under optimal conditions.

Processing parameters, including laser power and cutting speed, can be adjusted to suit the material, thickness, and desired quality, ensuring both efficiency and accuracy for a wide range of lightweight components.

# Disadvantages

## High Upfront Costs

Sheet metal fabrication often requires significant initial investment in tools, machinery, and custom equipment. Processes such as roll forming and stamping rely on specialized tooling, which can be expensive and only cost-effective for large production runs. While automation can reduce labor costs, it is typically justified only when manufacturing high volumes.

## Complex Bending Operations

Some bending and forming operations can be challenging, especially for thicker materials or intricate geometries. Complex bends may require additional tooling, careful setup, or manual intervention, which can increase production time and costs.

## Limited Designs

Although sheet metal is versatile, producing highly intricate or organic shapes is difficult. Unlike injection molding or 3D printing, which can achieve complex geometries, sheet metal fabrication generally results in components with simpler, boxy forms and straightforward appearances.

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# Tips to Reduce Sheet Metal Fabrication Costs

Sheet metal fabrication can be resource-intensive, and complex designs often increase production costs. By making smart design and process choices, you can significantly reduce expenses without compromising quality. The following eight tips will help you streamline fabrication, optimize efficiency, and lower costs—allowing you to get the most value from your sheet metal components.

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## 1. Consider Equipment and Materials

Sheet metal fabrication often involves significant upfront investment in tools and machinery. Processes such as roll forming and stamping require specialized equipment and custom tooling, which can be expensive and are typically cost-effective only for large production runs. Some operations may also require manual labor, increasing production costs. Automation can reduce labor expenses, but it is generally justified only when manufacturing high volumes.

Material selection has a direct impact on the overall cost of sheet metal fabrication. The goal is to choose the most cost-effective metal that still meets the performance and durability requirements of the part. For example, aluminum is generally less expensive than stainless steel while still offering good strength, corrosion resistance, and machinability for many applications. By selecting materials that balance affordability with function, you can significantly reduce production costs without compromising quality.

## 2. Use a Common Sheet Gauge

Designing with standard sheet sizes and gauges helps keep fabrication efficient and cost-effective. Non-standard gauges often require special orders, which can increase both material costs and lead times. By aligning your design with commonly available sheet gauges and selecting materials that are readily stocked in the market, you can reduce procurement expenses and avoid delays caused by sourcing uncommon specifications.

## 3. Avoid Welding and Plating

Welding and plating can significantly increase fabrication costs and should be minimized whenever possible. For example, welding pre-plated sheet metal may release hazardous fumes such as zinc oxide, requiring additional safety measures that raise production expenses. Similarly, uncoated cold-rolled steel often requires plating to improve corrosion resistance, but this additional process extends lead times and increases costs.

Whenever design requirements allow, consider alternative fastening methods (such as riveting or bolting) and material choices that eliminate the need for secondary plating. This approach reduces both costs and processing time while maintaining part performance.

## 4. Avoid Complicated Design Elements

While complex designs may add aesthetic value, they often drive up manufacturing costs. For example, incorporating numerous cuts or small bends in thick materials increases fabrication difficulty, requires multiple tools, and raises the risk of dimensional inaccuracies—all of which add to overall cost.

To keep fabrication efficient, designs should use simple, consistent bends with a steady bend radius whenever possible. Unnecessary features such as chamfered edges, blind holes, and machined pockets should be avoided unless they are functionally essential. Reducing these complexities helps shorten lead times, minimize errors, and lower production costs.

## 5. Optimal Bend Radius

Using optimal geometries in the part's design is another way to reduce metal fabrication costs. The internal bend radius must be between 0.030 inches (0.762mm) and the material thickness. Following this will enable manufacturers to form the radii with tools specifically for those geometries. There will be no need for a specialized toolset or other alternatives that may increase manufacturing costs.

## 6. Stick with Appropriate Tight Tolerances

Tighter tolerances significantly increase fabrication costs, as they require specialized tooling, more precise setups, and closer quality control. These tools are also subject to greater wear, leading to more frequent replacement and higher maintenance expenses.

Since only a few critical surfaces typically affect a part's functionality, it is best to apply tight tolerances selectively to those areas. Allowing standard tolerances on non-critical features helps maintain performance requirements while reducing unnecessary manufacturing costs.

## 7. Consider Fast, Frugal Fasteners

Custom-designed or complex fasteners can significantly increase both manufacturing costs and lead times. These specialized components often require additional tooling, labor, and assembly steps. To reduce costs and streamline production, it's more efficient to use readily available, standard fasteners that can be quickly sourced and easily integrated into the design. Opting for simple, cost-effective fasteners helps maintain functionality while keeping costs under control.

## 8. Consider Finishing Options that Minimize Costs

The choice of finishing process is influenced by factors such as the part's functional requirements, environment, and aesthetic needs. For example, if the component will be exposed to harsh conditions, using a pre-plated or corrosion-resistant metal may be the best choice to enhance durability and reduce the need for additional coatings.

To further reduce costs, it's beneficial to schedule finishing operations like silk screening, engraving, or painting at the final stages of production. This minimizes handling and potential rework, ultimately reducing overall production time and cost.



## The best place to source your rapid prototypes and custom parts

Addr: GangKou, ZhongShan City, GuangDong  
Province, China

Tel: +86 760 8841 1100

Email: [projects@3erp.com](mailto:projects@3erp.com)

Web: <https://www.3erp.com/>

