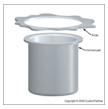
Cutting operation are those in which a piece of sheet metal is separated by applying a great force to make the material fail.

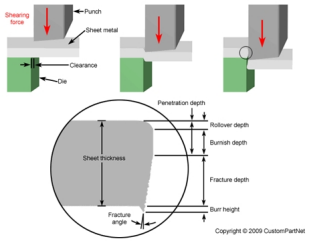
Sheet Metal Cutting (Shearing)



Cutting processes are those in which a piece of sheet metal is separated by applying a great force to make the material fail.

The most common cutting processes are performed by applying a shearing force, and are therefore sometimes referred to as shearing processes. When a great enough shearing force is applied, the shear stress in the material will exceed the ultimate shear strength and the material will fail and separate at the cut location. This shearing force is applied by two tools, one above and one below the sheet. Whether these tools are a punch and die or upper and lower blades, the tool above the sheet delivers a quick downward blow to the sheet metal that rests over the lower tool. A small clearance is present between the edges of the upper and lower tools, which facilitates the fracture of the material. The size of this clearance is typically 2-10% of the material thickness and depends upon several factors, such as the specific shearing process, material, and sheet thickness.

The effects of shearing on the material change as the cut progresses and are visible on the edge of the sheared material. When the punch or blade impacts the sheet, the clearance between the tools allows the sheet to plastically deform and "rollover" the edge. As the tool penetrates the sheet further, the shearing results in a vertical burnished zone of material. Finally, the shear stress is too great and the material fractures at an angle with a small burr formed at the edge. The height of each of these portions of the cut depends on several factors, including the sharpness of the tools and the clearance between the tools.



Sheared edge

A variety of cutting processes that utilize shearing forces exist to separate or remove material from a piece of metal sheet stock in different ways. Each process is capable of forming a specific type of cut, some with an open path to separate a portion of material and some with a closed path to cutout and remove that material. By using many of these processes together, sheet metal parts can be fabricated with cutouts and profiles of any 2D geometry. Such cutting processes include the following:

- Shearing- Separating material into two parts
- Blanking - Removing material to use for parts
- Conventional blanking
- Fine blanking
- Punching - Removing material as scrap
- Piercing
- Slotting
- Perforating
- Notching
- Nibbling
- Lancing
- Slitting
- Parting
- Cutoff
- Trimming
- Shaving
- Dinking

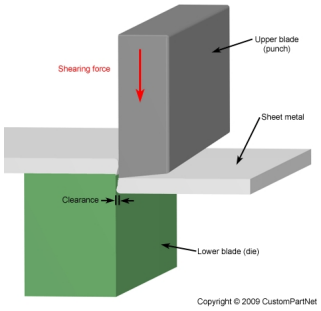
Shearing

As mentioned above, several cutting processes exist that utilize shearing force to cut sheet metal. However, the term "shearing" by itself refers to a specific cutting process that produces straight line cuts to separate a piece of sheet metal. Most commonly, shearing is used to cut a sheet parallel to an existing edge which is held square, but angled cuts can be made as well. For this reason, shearing is primarily used to cut sheet stock into smaller sizes in preparation for other processes. Shearing has the following capabilities:

- Sheet thickness: 0.005-0.25 inches
- Tolerance: ±0.1 inches (±0.005 inches feasible)

- Surface finish: 250-1000 µin (125-2000 µin feasible)

The shearing process is performed on a shear machine, often called a squaring shear or power shear, that can be operated manually (by hand or foot) or by hydraulic, pneumatic, or electric power. A typical shear machine includes a table with support arms to hold the sheet, stops or guides to secure the sheet, upper and lower straight-edge blades, and a gauging device to precisely position the sheet. The sheet is placed between the upper and lower blade, which are then forced together against the sheet, cutting the material. In most devices, the lower blade remains stationary while the upper blade is forced downward. The upper blade is slightly offset from the lower blade, approximately 5-10% of the sheet thickness. Also, the upper blade is usually angled so that the cut progresses from one end to the other, thus reducing the required force. The blades used in these machines typically have a square edge rather than a knife-edge and are available in different materials, such as low alloy steel and high-carbon steel.

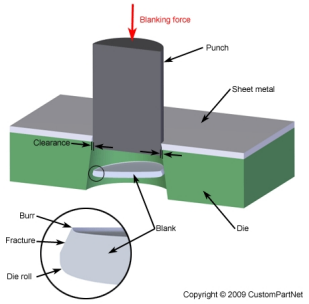


Shearing

Blanking

Blanking is a cutting process in which a piece of sheet metal is removed from a larger piece of stock by applying a great enough shearing force. In this process, the piece removed, called theblank, is not scrap but rather the desired part. Blanking can be used to cutout parts in almost any 2D shape, but is most commonly used to cut workpieces with simple geometries that will be further shaped in subsequent processes. Often times multiple sheets are blanked in a single operation. Final parts that are produced using blanking include gears, jewelry, and watch or clock components. Blanked parts typically require secondary finishing to smooth out burrs along the bottom edge.

The blanking process requires a blanking press, sheet metal stock, blanking punch, and blanking die. The sheet metal stock is placed over the die in the blanking press. The die, instead of having a cavity, has a cutout in the shape of the desired part and must be custom made unless a standard shape is being formed. Above the sheet, resides the blanking punch which is a tool in the shape of the desired part. Both the die and punch are typically made from tool steel or carbide. The hydraulic press drives the punch downward at high speed into the sheet. A small clearance, typically 10-20% of the material thickness, exists between the punch and die. When the punch impacts the sheet, the metal in this clearance quickly bends and then fractures. The blank which has been sheared from the stock now falls freely into the gap in the die. This process is extremely fast, with some blanking presses capable of performing over 1000 strokes per minute.



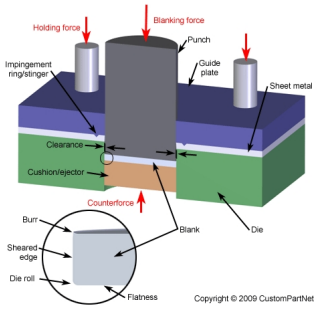
Blanking

Fine blanking

Fine blanking is a specialized type of blanking in which the blank is sheared from the sheet stock by applying 3 separate forces. This technique produces a part with better flatness, a smoother edge with minimal burrs, and tolerances as tight as ±0.0003. As a result, high quality parts can be blanked that do not require any secondary operations. However, the additional equipment and tooling does add to the initial cost and makes fine blanking better suited to high volume production. Parts made with fine blanking include automotive parts, electronic components, cutlery, and power tools.

Most of the equipment and setup for fine blanking is similar to conventional blanking. The sheet stock is still placed over a blanking die inside a hydraulic press and a blanking punch will impact the sheet to remove the blank. As mentioned above, this is done by the application of 3 forces. The first is a downward holding force applied to the top of the sheet. A clamping system holds a guide plate tightly against the sheet and is held in place with an impingement ring, sometimes called a stinger, that surrounds the perimeter of the blanking location. The second force is applied underneath the sheet, directly opposite the punch, by a "cushion". This cushion

provides a counterforce during the blanking process and later ejects the blank. These two forces reduce bending of the sheet and improve the flatness of the blank. The final force is provided by the blanking punch impacting the sheet and shearing the blank into the die opening. In fine blanking, the clearance between the punch and the die is smaller, around 0.001 inches, and the blanking is performed at slower speeds. As a result, instead of the material fracturing to free the blank, the blank flows and is extruded from the sheet, providing a smoother edge.



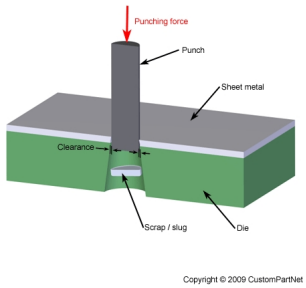
Fine blanking

Punching

Punching is a cutting process in which material is removed from a piece of sheet metal by applying a great enough shearing force. Punching is very similar to blanking except that the removed material, called the slug, is scrap and leaves behind the desired internal feature in the sheet, such as a hole or slot. Punching can be used to produce holes and cutouts of various shapes and sizes. The most common punched holes are simple geometric shapes (circle, square, rectangle, etc.) or combinations thereof. The edges of these punched features will have some burrs from being sheared but are of fairly good quality. Secondary finishing operations are typically performed to attain smoother edges.

The punching process requires a punch press, sheet metal stock, punch, and die. The sheet metal stock is positioned between the punch and die inside the punch press. The die, located underneath the sheet, has a cutout in the shape of the desired feature. Above the sheet, the press holds the punch, which is a tool in the shape of the desired feature. Punches and dies of standard shapes are typically used, but custom tooling can be made for punching complex shapes. This tooling, whether standard or custom, is usually made from tool steel or carbide. The punch press drives the punch downward at high speed through the sheet and into the die below. There is a small clearance between the edge of the punch and the die, causing the material to quickly bend and fracture. The slug that is punched out of the sheet falls freely through the tapered opening in the die. This process can be performed on a manual punch

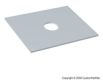
press, but today computer numerical controlled (CNC) punch presses are most common. A CNC punch press can be hydraulically, pneumatically, or electrically powered and deliver around 600 punches per minute. Also, many CNC punch presses utilize a turret that can hold up to 100 different punches which are rotated into position when needed.



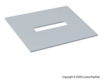
Punching

A typical punching operation is one in which a cylindrical punch tool pierces the sheet metal, forming a single hole. However, a variety of operations are possible to form different features. These operations include the following:

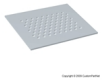
- Piercing - The typical punching operation, in which a cylindrical punch pierces a hole into the shee



- Slotting - A punching operation that forms rectangular holes in the sheet. Sometimes described as



- Perforating - Punching a close arrangement of a large number of holes in a single operation.

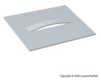


- Notching - Punching the edge of a sheet, forming a notch in the shape of a portion of the punch.

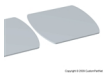
- Nibbling - Punching a series of small overlapping slits or holes along a path to cutout a larger conto

- Lancing - Creating a partial cut in the sheet, so that no material is removed. The material is left atta

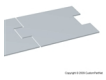
- Slitting - Cutting straight lines in the sheet. No scrap material is produced.



- Parting - Separating a part from the remaining sheet, by punching away the material between parts

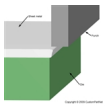
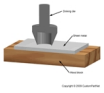


- Cutoff - Separating a part from the remaining sheet, without producing any scrap. The punch will p



- Trimming - Punching away excess material from the perimeter of a part, such as trimming the flang

- Shaving - Shearing away minimal material from the edges of a feature or part, using a small die cle



- Dinking - A specialized form of piercing used for punching soft metals. A hollow punch, called a dir