

## Fay Butler's Metal Shaping Glossary

Every trade requires a commonly established and used language. Without one it can be very difficult to communicate ideas between craftsmen. This common language will continue the development and progression of ideas crucial in a profession.

In my opinion, this language should come from accepted science, whenever possible. Examples would be phrases used in the metallurgy field such as "metals are a crystalline structure, not a molecule; rust and oxides are a molecule," and then others should be very simple in nature and descriptive, like "linear contacts," "linear stretch dies," or "radial contact" or have an origin and respect for history, like "Shape and Form," that came to me from past employee's at that now closed company called California Metal Shaping.

It is not our desire to have these terms feel intimidating, although some will be new and unfamiliar until understood. With time, and in the case of established languages like that of material science and metallurgy, further reading of well-respected books will also help.

This section is our attempt, along with the acceptance and participation of John Glover to establish a professional language.

In my opinion, if you read this list of terms, learn to understand them, and use them regularly, this can start a baseline of thought that will help move you into a professional mindset.

**Accelerate** - A changing arc over a given distance at some rate.

**Anneal** - A time/temperature-dependent operation where stressed/cold worked metal is heated above a critical temperature and cooled, allowing for a decrease in tensile strength with a resultant increase in ductility, leaving an unstrained, finer grain crystal. See *Stress Relief* and *Normalizing*.

**Anvil** - The bottom die holder.

**Atom** - Basic unit makeup of all elements.

**Austenite** – Above the upper critical temperatures, carbon dissolves in a solid solution of iron. This occurs when below the critical temperature in a body-centered cubic lattice pattern (iron), which has nine atom spaces, transforms into a face-centered cubic lattice pattern, which now has fourteen atom spaces. When rapidly cooled carbon is trapped, distorting the crystal, leaving the hardened state of martensite.

**Cementite** - An intermetallic compound of iron and carbon ( $\text{Fe}_3\text{C}$ ) containing 6.68% carbon. A hard brittle iron carbide with low tensile strength.

**Coining** - A pressing operation between a male and female die where the metal is set under compression.

**Compound Curve** - A panel that has a curve in one direction as well as the perpendicular direction. They are achieved through the thickening and thinning of the material (Shrinking and Stretching). High crown, low crown, and reverse curves are the three types of compound curves.

**Contact Area** - The area of the die that hits the sheet metal causing a change in thickness.

**Crown** - The depth of a dished panel. When a straight edge is placed on the panel it will rock in all directions.

**Crystalline Structure** - When metals solidify from a liquid, the atoms arrange themselves in this densely packed, organized geometric shape. The building blocks of these groups of atoms are known as lattice patterns. The groupings of lattice patterns together, in a close packed, neat arrangement is due to the atom's natural forces of attraction and repulsion. See *Lattice Pattern*.

**Dislocations** - Faults that enable metal crystals to slip at stresses way below those that would be required to move two perfect crystal planes past one another. "Edge" or "Screw" dislocations, which form a line to the crystal edge. Without these natural defects, metals would not be formable.

**Dome** - A shape with the same true radius in both directions or planes.

**Edge Radius** - One that accelerates off from a flat or true radius to eliminate all sharp edges. A hammer die with a sharp edge on it has the potential of "digging in" and seriously marking the panel. See *Lead-In*.

**Elastic Limit** - As the stress rises elastically, it is the point above which the metal yields and starts to move plastically along slip planes, with permanent deformation.

**F=MA** - The Newtonian law, Force = Mass x Acceleration

**False Shrink/Stretch** - "Displacement problems" or dents in the part that need to be bumped up. No additional shaping is required. These are form problems.

**Ferrite** - Pure iron and very plastic; abbreviated Fe on the Periodic Chart.

**Flange** - A turned edge used to strengthen, guide, or for the attachment to another object.

**Form** - The component of a compound curve where the part is folded (brake work or bending/folding with ones hands). Generally considered to have no change in thickness.

**Grains** - Groupings of organized atoms or lattice patterns with defined perimeter boundaries. See *Crystalline Structure*.

**Hard Spot** - The panel is touching the buck at a given spot. In the case of a standard crown, this requires additional stretching (shape) to rise up the low. In the case of a reverse curve, the opposite, or “reverse,” procedure is true.

**High Crown** - A compound curve panel requiring large shape changes. Generally roughed out by shrinking, fine tuned by stretching. Rounder panels, like a classic car fender or wheel wells, are high crowns.

**Highlight Line** - The area of most light reflection where two imaginary arcs or sweeps intersect showing the outline of the part. This can be a “sharp” true edge or some softened radius which accelerates over a lead-in, into the adjoining surfaces.

**Lattice Pattern** - A uniform geometric pattern which atoms naturally arrange themselves into when metals go from liquid to solid. There are seven major groups allowing for 21 variations, of which three are found universally in metals. FCC (Face Center Cubic-Aluminum), BCC (Body Center Cubic-Steel), HCP (Hexagon Close Packed-Magnesium).

**Lead-In** - A transition area on a die or tool front allowing the metal to progressively move to a specific profile.

**Linear Contact** - The contact area of a die involving a dominant axis, similar to a straight line. The die, for example, consists of a flat top in one axis and a given true radius in the other giving a full-length contact on one dimension.

**Loose Edge** - The edge, or part of it, is wavy looking. Additional stretching (shape) is required inboard of this edge to tighten it up, or equalize the area. This may be purposely introduced to aid in the removal of excess shape inboard. Often called “lettuce.”

**Low Crown** - A compound curve panel requiring small shape changes. Generally developed by stretching. Flatter panels like a door skin or deck lid are low crowns.

**Martensite** - The hardened state of higher carbon steel that has been heat treated.

**Maximum Die Contact** - When shaping, use the flattest die radius possible before the edges dig in. Often achieved by hand-manipulating the form of a compound curve to average the two perpendicular sweeps. Stretching the part may require a higher crown die.

**Normalizing** - A heating and air cooling process used for plain carbon or low alloy steels resulting in a finer and stronger pearlite grain structure than obtained by full annealing. Temperatures are above 1360°F, the lowest temperature in the upper critical range, with 1600°F being common. A sub-group of *annealing*.

**Pearlite** - A mixture of ferrite and cementite in carbon steel when solidified in the annealed state. When the carbon content is below 0.8% carbon, the ratio is 13% cementite and 87% ferrite, the lower the carbon content, the lower the proportion of pearlite and the better the plasticity of working steel cold. At 0.008% carbon pearlite is non-existent, and at 0.8% carbon, pearlite is 100% of material.

**Planish** - To level, make smooth, toughen and/or polish by hammering lightly.

**Plastic Working** - The ability of a material when stressed to undergo a permanent shape change without tearing.

**Pullmax** - 1) A specific company which makes a universal sheet metal machine 2) A generic name for a style of machines known more specifically as a universal sheet metal machine manufactured by a number of different independent firms.

**Radial Contact** - The contact area of a die, resembling a circle that increases evenly from a central point as the force increases.

**Recrystallization** - A time/temperature process similar to annealing. With heat, electrons (the charged particles making up the atom) move faster, taking more space (metal expands) permitting the atoms to rotate to realign themselves, back to the less strained, relaxed equilibrium in relation to surrounding atoms. Critical temperatures for recrystallization in pure metals (general temperatures): Aluminum 600°F, Iron 850°F, Copper 400°F. The more heat and time above this recrystallization or annealing temperature the easier for normal, unstrained crystalline structure to develop. See *Anneal*.

**Reverse Curve** - The opposite or “reverse” of a high or low crown curve. It is the process of first stretching one or more edges of a panel, then blending the stretch part inboard. When you place a straight edge on the reverse curve, the straight edge will rock in one plane and be hollow 90° from it. This type of shape is sometimes referred to as a “saddle shape.”

**Shape** - The aspect of a compound curve where the thickness of the panel is changed (shrinking and stretching).

**Slip Planes** - Natural lines of fault or weakness in solid materials.

**Soft Spot** - The panel has excess material in this area. An oil can effect on a flat panel or when resting on a buck. Will require shrinking where loose or stretching outside the problem area to an open edge.

**Strain Hardening** - When cold-working metal, atom spacing becomes distorted resulting in pinned dislocations, resisting further movement. This increases tensile strength, with subsequent loss in ductility, along with an increase in hardness. There is a reduction in electrical conductivity and a decrease in corrosion resistance. See *Work Hardening*.

**Stress Relief** - A heating and cooling process used to remove residual stresses from cold working and welding. For example, cold-worked carbon steel is stress relieved between 925° to 1200° F for one hour. A sub-group of *annealing*.

**Sweeps** - True radius arc templates or gauges traditionally numbered from 1 to 100, 24" to 60" long, 2" to 4" wide, and 1/8" to 1/4" thick. The numbers indicate the quantity of 1/8" rise of a true radius over a 60" cord. They can be constructed from plastics, aluminum, steel, or even wood. Developed by Harley Earl in 1927 when he set up the first design studio at General Motors. All automobile shapes after 1927 are developed using these gauges.

**True Radius** - A set distance that extends 360° around from a given center point. A true radius die, no matter where contact is made or the amount of energy applied, will always give a predictable, round contact. An arc used on sweeps.

**True Edge** - Intersection of two planes or surfaces to form a visible hard edge highlight line.

**Universal Sheet Metal Machine** - A style of machine used for general sheet metal work. These are powered machines with a specific stroke, made out of plate stock, with an upper driven mechanism fastened to the top and an adjustable lower mechanism, both holding some sort of post tooling with an adjustable panel guide. These machines incorporate features that nibblers and trimmers have, with expanded uses.

**Vacancies** - A point defect in a crystal or grain where an atom or atoms are missing. Vacancies allow for soldering and brazing where lower melting temperature materials diffuse into the solid metal as "tentacles" filling the vacancies, allowing for a mechanical joint.

**Wash Over** - When a panel is considered finished or in trouble, it will have a certain amount of tension to it. Use the flattest possible contact die with even pressure and continuous contacts touching or overlapping. This will relieve the tension. A good panel will feel floppy, rather than tight and springy.

**Work Hardening** - When spaces between atoms are no longer uniform in all directions. This increases tensile strength, with subsequent loss in ductility, along with an increase in hardness. There is a reduction in electrical conductivity and a decrease in corrosion resistance.