

## Stainless Steel - Fabrication

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The single most important thing to remember when fabricating a product from stainless steel is to ensure that the fabrication processes retain and do not compromise the intrinsic properties of stainless steel. Fabrication of all stainless steels should be done only with tools dedicated to stainless steel materials.

Tooling and work surfaces must be thoroughly cleaned before use. These precautions are necessary to avoid cross contamination of stainless steel by easily corroded metals that may discolour the surface of the fabricated product.

Tools and blades must be kept sharp and clearances, for example between guillotine blades, must be tighter than for Carbon steels.

### Forming Speeds

Unlike Carbon steels, work hardening rates for stainless steels mean that more severe deformation is possible at slower forming speeds. For forming operations normally performed at high speed, like cold heading, it is recommended that the process is slowed.

### ADVANTAGES

Apart from the commercial reasons for choosing stainless steel as a material, like heat and corrosion resistance, another advantage is its fabrication properties. The austenitic grades in particular can be fabricated by all standard fabrication methods. Some techniques are more suited to particular stainless grades than normal carbon steels. This is well demonstrated for severe deformation procedures such as deep drawing.

Due to stainless steel tending to have higher strength and work hardening rates than carbon steel, some alteration to tooling and equipment may be required: A more robust machine may be required due to the high strength of stainless steel.

For the same reason the capacity of a machine, such as a guillotine may be only 60% of its carbon steel capacity.

Greater deformation than used for carbon steels may often be necessary due to spring-back after forming. For example in tube making a different roll set design to that used for carbon steel will be required as a higher degree of over-bending is necessary.

### DRAWING

Cold drawing can produce components in 301, 302 and 304 with tensile strengths in excess of 2000 MPa due to work hardening. Producing components at these strengths is limited to very thin sections and fine wires.

With increasing section thickness the amount of cold work required to produce these strengths also increases to the point that it cannot be done practically. This is due to the surface of stainless steel work hardening more rapidly than the interior of the material. Work hardening the entire cross section of larger diameters requires exceptional and impractical forces.

Austenitic stainless steel can be used to produce deep drawn components that require very high elongations and thus stainless steel is widely specified for the production of hollowware.

### CUTTING

Most grades of stainless steel can be cut using standard cutting methods employed for other metals.

The work hardening rate of stainless steels sometimes means heavier equipment and specialist blades or cutting edges are required. Consideration must also be given to changes in the heat affected zone when the cutting method generates high heats along the cut.

Common cutting methods include:

- Plasma cutting
- Laser cutting
- Water jet cutting
- Bandsawing
- Slitting
- Guillotining
- Abrasive disc cutting

### BENDING

Like many other fabrication methods for stainless steel, bending can be done using the same equipment used to bend other metals. A difference is that working hardening rates may mean a need for more rigid equipment and higher power levels. Equally, equipment capacity will be much lower than for Carbon steels.

#### Bar and flat bending

Round bar, flat bar, sheet and plate can be bent using a press brake, bending machine or ring-rolling. Due to work hardening, bending should be done quickly. Some over-bending will be required to counteract spring-back of the bend. The inside bend radius should not be smaller than the thickness of the material being bent.

#### Tube bending

Tube bending is often done for architectural and other applications.

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Bending of stainless tube can be difficult unless done by persons experienced in the field. Rotary bending and hydraulic press bending can both be employed to bend stainless steel tube.

Centre line bend radii should not be smaller than twice the tube diameter.

### WELDABILITY

Most grades of stainless steel can be welded by all traditional welding methods. However, the weldability of different grades can vary considerably. Some austenitic grades are considered to be the most readily welded metals. Weldability is generally low for ferritic and martensitic grades. For some grades, such as 416, welding is not recommended at all.

Recommended filler rods and electrodes vary depending on the grade being welded.

### MACHINABILITY

A commonly held belief is that stainless steel is difficult to machine. Machining can be enhanced by correct grade selection and using the following rules:

- Cutting edges must be kept sharp. Dull edges cause excess work hardening.
- Cuts should be light but deep enough to prevent work hardening by riding on the surface of the material.
- Chip breakers should be employed to assist in ensuring swarf remains clear of the work.
- Use lubricants in large quantities.

Stainless steels like 303 and free machining grades have Sulphur included in the composition. This produces a marked increase in machinability but reduces both corrosion resistance and weldability.

Over the years manufacturers of stainless steel bar have greatly improved the machinability of standard 304 and 316 grades. This has been achieved by careful control of compositions and production process variables that avoid the detrimental effect seen with Sulphur-bearing grades. This means the point has now been reached where many specifiers and machine shops have switched away from 303.

### FINISHING

Although stainless steels have excellent corrosion resistance, and are often selected for this property, proper finishing is required to

maintain it. After any fabrication process that alters the surface condition of the material, the stainless steel needs to be degreased, cleaned and finished appropriately.

Finishing methods may include one or more of the following:

- Pickling
- Passivation
- Grinding
- Electropolishing
- Mechanical Polishing
- Blackening
- Colouring

### Pickling

Pickling uses an acid or mixture of acids to remove scale produced in high temperature operations like welding, heat treatment or hot working. Acids and procedures depend upon the grade of stainless steel being treated. A great deal of care must be taken during the pickling process and with disposal of the waste as the acids used include sulphuric acid, nitric acid and hydrofluoric acid.

Pickling also removes rust due to corrosion of the stainless steel or corrosion of contaminant iron and steel particles.

The scale is removed as it retards the corrosion resistance of the underlying stainless steel.

Pickling is commonly done using baths or "Pickling Paste". Pickling paste is a specially prepared stiff paste of strong acids. In this form it can be applied to vertical or overhanging surfaces and localised areas.

Pickling paste is often employed to remove post-weld discolouration.

These are strong acids and appropriate caution must be taken when handling them. The same applies with acids used in passivation.

### Passivation

Passivation is a process used to remove any free iron contamination of the stainless surface. Iron in the form of elemental iron, cast iron, carbon steel, mild steel or other non-stainless alloys can cause problems with stainless steels. This material is normally deposited from tools or work surfaces during fabrication. The iron particles promote corrosion on the surface of the stainless steel.

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At its mildest form, the discolouration caused can be unsightly. More serious corrosion is isolated pitting corrosion at the point of contamination.

Passivation involves treatment of the stainless steel with nitric acid or a nitric acid and sodium dichromate combination to remove the iron contaminants.

### Grinding

Stainless steels are readily polished and ground if standard techniques are slightly modified. A build up of material on abrasive media occurs due to the high strength of stainless steels. Low thermal conductivity means that there is also a build up of heat. The result can be heat tinting of the surface of the material.

Using low grinding and feed speeds combined with specifically selected lubricants and grinding media can alleviate these complications.

Corrosion resistance of stainless steels tends to increase with the extent of surface polishing.

### Electropolishing

The reverse of electroplating is electropolishing. This is an electrochemical process that removes the peaks of the rough surface of a metal. Electropolishing smooths the material surface making it brighter.

The resultant finish is very corrosion resistant, hygienic and attractive. On some stainless steels the surface finish appears frosted rather than smooth and reflective.

### Blackening

Occasionally a highly polished surface is not wanted for stainless steel. In this case blackening is used to produce a non-reflective black oxide surface. Several methods can be used to achieve this finish.

Some treatments are proprietary but two common methods are immersion in a solution of sulphuric acid and potassium dichromate solutions or immersion in a molten salt bath of sodium dichromate.

### Mechanical Polishing

Any mechanical polishing procedures must be carefully done to ensure contamination by iron based materials doesn't occur.

Sand blasting must be done with clean silica or garnet sand. Shot, grit and cut wire blasting must use stainless steel media of equal or greater corrosion resistance than the metal being cleaned. Barrel and vibratory finishing are often used to polish fittings and small parts.

Light heat tint can be removed by wire brushing but the brushes must be stainless steel and never be used on other materials.

Mechanically cleaned parts are not as corrosion resistant as pickled stainless steel. This is due to mechanical cleaning not removing all the chromium depleted material from the surface and the retention of some scale residue. Mechanical cleaning is often used to prepare the surface of stainless steel before pickling.

### Colouring

Stainless steels can be given a range of surface colours for architectural applications. These colours include bronze, blue, gold, red, purple, black and green. A range of shades can also be produced.

The colouring is done by a proprietary process that involves immersing the stainless steel in a hot chromic/sulphuric acid solution. This is followed by a cathodic hardening treatment in another acidic solution. The base material reacting with the hot acid produces a transparent film. Although the film is colourless, light interference imparts a colour to the layer. If the underlying metal surface is highly polished the effect will be a strong metallic lustre. For matt and satin finished stainless steel, the result will be a matt finish.

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