Laser Cutting

by Mike Williams

First Published in

Newsletter 66

September 2006

There are two main ways in which metal can be reduced in size: metal removal and metal cutting. The former includes filing, grinding, milling and spark-erosion techniques to remove small chunks until the correct shape is obtained. The latter includes sawing and shearing of mainly flat sheets to form shapes. Increasingly the cost of using high-tech equipment has come down to the level where the individual can consider using it for hobbies, such as model making, so this account looks specifically at laser cutting parts for models.

Cutting steel with a laser beam has been around for many years now, but only in the last 15 to 20 has it been cheap enough for us amateurs to consider using. I guess the first model parts to be laser cut were locomotive frames because they have to be made exactly to size and a matched pair. Most large towns now have an engineering company nearby with a laser cutting machine capable of an accuracy of at least one thou. Indeed there seems to be an over-supply at present, so it is cheap.

The laser cutter is controlled by a computer program (Computer Numerical Control or “CNC”), but that shouldn’t frighten anyone. Modern machines can read drawing files direct from Autocad, and also read .DXF files which can be produced by almost all modern drawing software packages on your home PC. Most fabrication companies are used to dealing with customers who have no draughting skills, so will undertake the CAD work for you from a good dimensioned sketch, for a commercial fee.

In theory all metals, plastic, glass and wood can be cut, but most common are mild and stainless steels, aluminium, brass and copper. They can handle materials from about 20mm thick, down to less than 1mm. It is possible to cut much thicker materials, like 4in thick steel for armour plating, but your local firm will probably not be able to do so. The maximum size of the sheet is governed by availability of the material, as many laser machines have beds up to 7 metres by 2 metres. They are typically mounted on a huge cast iron bed which is surrounded by solid rubber (or should I say polyurethane resin!) inside a pit cut into the floor of the building. They are thus insulated from vibrations from other equipment nearby. The machines require servicing and adjusting, and I have found that the quality of the cut is partly governed by how recently the machine was serviced.

One query I had was the thickness of the cut line. I knew this was very little, but when making parts to slot together it should still be taken into account. My local firm near Leighton Buzzard however told me that the machine works out which part is wanted and which is the waste, and adjusts the location of the cut so as to leave the part exact size. Now that’s clever!

In general circular holes can be cut to any size down to the thickness of the metal. In other words, in 1mm steel the smallest hole should be 1mm diameter. An exception however is ‘spotting’ where, instead of the material moving as the laser is active, the machine is stopped, the laser turned on for a burst and then turned off, leaving a hole the size of the laser beam, which can be typically down to about 0.4mm.

Obviously the laser beam is extremely hot – 13,000 degrees C - and with thin materials the local build-up of heat can melt the surrounding metal (mild steel melts at 1515 degrees C) and literally blow it away. For that reason square corners should be avoided as the workpiece will stop, change direction, and then restart, all whilst the laser is still active. Better to have even a tiny radius so that the beam stays moving. Even so, some small pieces we need for modelling will be quite beyond the conventional laser cutter as the metal doesn't have time to cool before the adjacent hole is cut. One way round this is to use an argon shield around the laser. This is like a ring, or tube, of cool argon gas which cools the metal immediately it has been cut. This is used for stainless steel and your local firm, like mine, may only be prepared to cut stainless in this way. This is not them being difficult, but the machine is programmed for the type of material and recalibration to use argon for mild steel is not practical. In this way I have cut six 1mm holes in a brake pushrod: two rows of three holes, all in a total space less than 5mm long by 2.5mm wide.

Laser cutting machines can do all sorts of other fancy things, like cut part-way through the material, and cut wood, plastic or even cardboard, but very few companies regularly cut these materials and I had great difficulty finding anyone willing to spend time adjusting their machines to do plywood and my local company no longer cuts plastic because they are uncertain what toxic fumes may be produced and don't want to take any risks. There are some excellent kits for narrow gauge carriages and buildings laser cut from plywood, but every one of those I found turned out to be made in the USA by one man who has since given up and found himself a proper job! I did find a UK company able to cut MDF – down to 6mm, which is not a lot of use for Gauge 3 carriages!

I have recently been experimenting with laser cut carriage body parts using stainless because it is readily available and cheap, though if they ever reach production this may be changed for something easier to bend. The artwork is very similar to that for etched brass, except that half-etched lines are avoided. Separate drawings are prepared for the sides and the beading, and allowance made for lapped corner joints and slot-and-tab location. Holes and slots are cut for door hinges and handles, commode handles and any other detail, and since most of these holes are in both the side and the panelling, they help to keep the parts aligned during assembly.

I hope I have shown that laser cutting is easy and cheap, but what are the drawbacks?

The materials are limited and not necessarily the types one would choose for bending or rolling. It is not practical to cut half way through as an aid for folding, and heat build-up may be a problem with some materials. The laser heats mild steel to red and then allows it to cool slowly, effectively hardening the edges, so adjusting any holes which are not exactly correct can be more difficult that expected.

As for the cost, with machines costing from £200,000 to several million, the cost usually relates to the amount of time your work will tie up their machine, plus optionally a set-up charge and the cost of the material. If using stainless there may also be a charge for the argon gas. A typical charge is £100 - £200 per hour of machine time including setting up. Machines work at various speeds partly depending on the material and thickness, but since your local company will probably not have the latest machines, if you base your calculations on 2 metres per minute of cut you'll be on the safe side.

And what are the alternatives?

Flame cutting is common in heavy industry and the process involves an oxy-acetylene or oxy-hydrogen flame to cut carbon and low alloy steel. For modelling it is no longer viable and has been completely superseded by laser cutting.

Water jet cutting uses an ultra-high pressure (c60,000psi) water jet with the addition of abrasive particles. Almost any material can be cut cleanly to close tolerances, squarely and with a good edge finish. Water jet cutting creates super-smooth cut surfaces that have no heat affected zone, no burrs or slag. The process cannot of course be used on materials which deteriorate when wet. Another drawback seems to be that the jet is about 1mm thick and oscillates. This means the smallest holes that can be cut is about 2mm, and although slots 1mm wide can be cut, they will have 2mm diameter holes at either end. For locomotive frames that is probably not a problem, but for instance where .7mm thick stainless steel is to be held together with slots and tabs, the slot will be too wide to provide a snug fit. If anyone has found a company able to water jet cut without this constraint, then I would be interested to hear of them.

Plasma arc cutting has been around for fifty years and was used for metals that could not be flame cut, such as stainless steel, aluminium and copper. The plasma arc cutting process uses electrically conductive gas to transfer energy from an electrical power source through a plasma-cutting torch to the material being cut. The plasma gases include argon, hydrogen, nitrogen and mixtures, plus air and oxygen. This is of little use for modelling today.

I guess there is one other alternative which should never be dismissed – the humble piercing saw!