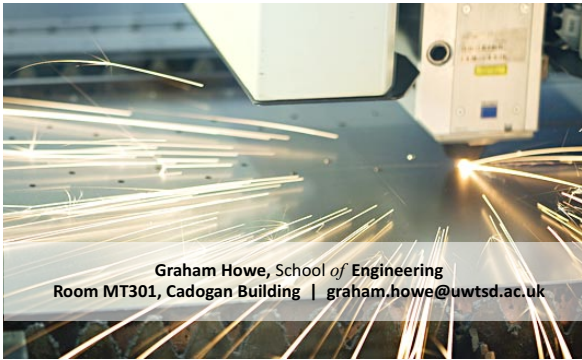


Laser Cutting



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Laser Cutting



What did we look at last time?

- Use of Lasers for Rapid Prototyping and Rapid Tooling solutions
- To recap the background to lasers;
 - Movie Clip of History of Lasers ([Weblink](#))

Laser Cutting



- Laser cutting has been used in industry since the 1970's
- First common application was for acrylic sign making.
- Now it's a significant process in every manufacturing economy



Laser Cutting

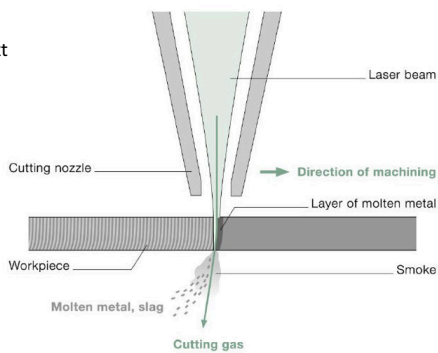


- Laser cutting is a technology that uses the laser to 'cut' materials such as metal, ceramics, paper and polymers.
- Two Types of lasers used for cutting;
 - Gaseous CO₂
 - Solid State Nd:YAG
- CO₂ lasers are used for industrial cutting of many materials including mild steel, aluminum, stainless steel, titanium, paper, wax, plastics, wood, and fabrics.
- Nd:YAG lasers are primarily used for cutting and scribing metals and ceramics.

Laser Cutting



- Text



Laser Cutting



- Where the focused laser beam strikes the workpiece, it heats the material so extremely that it melts or even vaporizes.
- Once it has completely penetrated the workpiece, the cutting process can start: the laser beam moves along the part contour, melting the material as it goes.
- Usually, a stream of gas blows the melted material downwards, out of the cut. The gap is barely wider than the focused laser beam itself.
- In laser drilling, a short laser pulse melts and vaporizes the material with a high power density.
- The resulting high pressure drives the molten material out of the hole.

Laser Cutting



- In flame cutting, oxygen is used as the cutting gas.
- The oxygen is blown into the kerf at pressures of up to 6 bar.
- There, the heated metal reacts with the oxygen: it begins to burn and oxidizes.
- The chemical reaction releases large amounts of energy – up to five times the laser energy – and assists the laser beam.
- Flame cutting makes it possible to cut at high speeds and handle jobs involving thick plates such as mild steel with thicknesses in excess of 30 millimeters.

Fusion Cutting

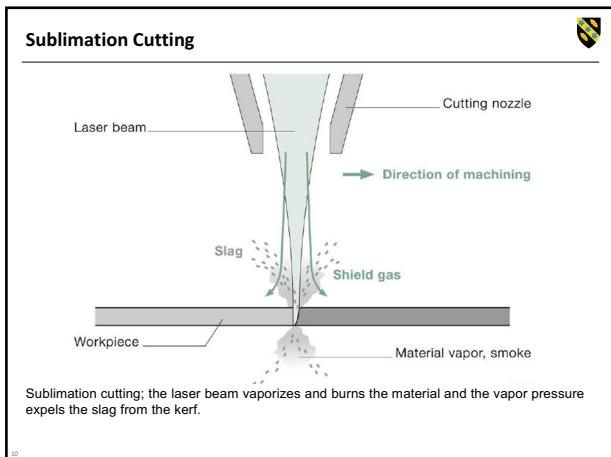


- The Nitrogen or argon gas is blown through the kerf at pressures ranging from 2 to 20 bar. Argon and nitrogen are inert gases.
 - This means that they do not react with the molten metal in the kerf. They simply blow it out toward the bottom. Simultaneously, they shield the cut edge from the air.
- The great advantage of fusion cutting;
 - Cut edges are oxide free and do not require further treatment. Nevertheless, the laser beam must supply all of the energy needed for cutting. For this reason, cutting speeds as high as those in flame cutting can be achieved only in thin sheets.
- Piercing is also more difficult.
 - Some cutting systems allow you to use oxygen to pierce the material and then switch over to nitrogen for cutting.

Sublimation Cutting



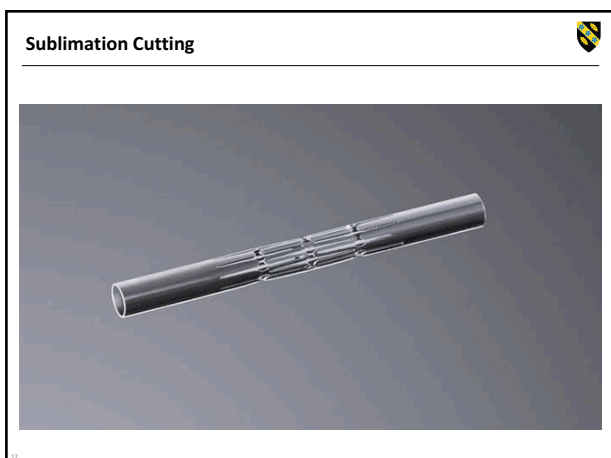
- In this process, the idea is to use the laser to vaporize the material with as little melting as possible. In the kerf, the material vapor creates high pressure that expels the molten material from the top and bottom of the kerf. The process gas – nitrogen, argon, or helium – serves solely to shield the cut surfaces from the environment. It ensures that the edges remain oxide free. For this reason, a gas pressure of 1 to 3 bar is sufficient.
- More energy is needed to vaporize metal than to melt it. For this reason, sublimation cutting requires high laser power and is slower than other cutting processes. However, it produces high-quality cuts.



Manufacturing Technology

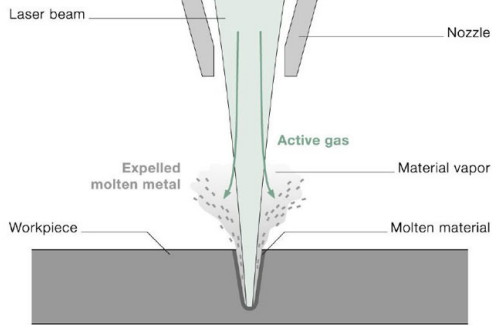
Sublimation Cutting

- This process is rarely used in sheet metal fabrication. Its use, however, becomes attractive in applications involving particularly delicate cutting work.
- Such applications include the production of stents.
- In metal processing, sublimation cutting is the exception; with nonmetals, it is very common. Many non-metal materials are regularly processed with sublimation cutting. Typical materials include:
 - Plastic sheeting and textiles, which vaporize even when only a small amount of energy is applied
 - Materials that do not melt, such as wood, cardboard, or foam



Manufacturing Technology

Laser Drilling



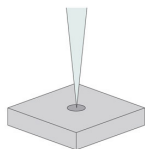
Laser Drilling

- In laser drilling, a short laser pulse with high power density feeds energy into the workpiece extremely quickly, causing the material to melt and vaporize.
- The greater the pulse energy is, the more material is melted and vaporized. Vaporization causes the material volume in the drilled hole to increase suddenly, creating high pressure.
- The vapor pressure expels the molten material from the hole.
- Over the years, several drilling processes have developed from the basic method;
 - Single-shot and Percussion Drilling
 - Trepanning
 - Helical Drilling

Laser Drilling

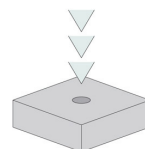
Single-shot Drilling

- A single laser pulse with comparatively high pulse energy is used to produce the hole.
- This method enables a large number of holes to be created in an extremely short amount of time.



Percussion Drilling

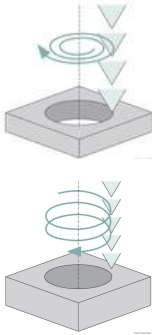
- The hole is produced using multiple short-duration, low-energy laser pulses.
- This technique produces deeper, more precise holes than single-shot drilling and also enables smaller hole diameters.



Laser Drilling



- **Trepanning** also uses multiple laser pulses to produce the hole. In this process, a pilot hole is first created using percussion drilling.
- Then the laser enlarges the pilot hole, moving over the workpiece in a series of increasingly larger circles with most of the molten material being expelled downward through the hole.
- Unlike Trepanning, **Helical Drilling** does not involve the creation of a pilot hole.
- The laser begins moving in circles over the material as the pulses are delivered, with a large amount of material shooting upward in the process.
- The laser continues to work its way through the hole in a downward spiral. The focus, meanwhile, can be adjusted so that it is always at the base of the hole.



Manufacturing Technology



Laser Cutting Economics

- Whilst most suited for precision cutting of sheet in the 1mm to 15mm thickness range, both CO₂ and Nd:YAG laser cutting systems require high capital investment.
- The cost of laser equipment can range from £50k-£250k depending on the output power requirements of the system.
- Precision work handling tools are required if a laser is to be used to its full potential, in terms of cutting speed and quality, this can add a further £100k to the cost of implementing a laser system.
- Typically used where high cut quality requirements make their application essential, or where the initial investment is offset by the high production rates that can be reached as a result of their high cutting speeds.

Laser Cutting Issues



- **Kerf**
 - Defined as the width of the cut at its widest point in millimetres, the kerf gives an indication of the minimum internal radius or feature that can be cut. Laser cuts possess a narrow to very narrow kerf width (0.5-1.0mm) for CO₂ and Nd:YAG lasers respectively.
- **Heat Affected Zone (HAZ) width**
 - HAZ width is defined as the width of a detectable microstructural change measured perpendicular to the cut edge face.
 - This is only applicable to alloys that are hardenable or heat treatable.
 - The width of the HAZ is of interest because, due to the potential degradation of properties and this material may have to be removed before final assembly of the product.
 - The concentrated heat source produced by both CO₂ and Nd:YAG lasers produces a very narrow HAZ (<0.5mm).

Laser Cutting Economics



Material	Power (Watts)	Speed (mm / min)	Cost (Per meter)
3mm Aluminum	5000	6500	£0.06
5mm Mild Steel	4800	2000	£0.19
25mm Mild Steel	5500	800	£0.47
32 mm Mild Steel	5500	580	£0.65
6mm Stainless Steel	6000	2800	£0.13
25mm Stainless Steel	7000	275	£1.37

* Assumes 1,000 litres gas consumption / hour & £0.23 / litre costs

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Laser Cutting Advantages



- Contamination of materials while laser cutting is reduced as there is no real physical contact between metal and cutter.
- Great accuracy as laser can be focused into very small points, and there is also no wear in a laser while it is cutting as there is with more conventional methods, such as milling.
- There is also a reduced chance of warping the material when laser cutting as the laser only generates a small area of heat.
- No mechanical force is applied therefore no physical damage can occur.

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Laser Cutting Dis-advantages



- Laser cutting has high energy consumption, and can draw a lot of power to perform its cutting.
 - Although it uses a large amount of power it goes some way to making up for this cost with its fast and precise cutting speed.
 - The cost and setup of a laser cutter can also be expensive when compared to other methods.
- Work hardening along the edges of cuts can mean harder work if any further machining is required.

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Futher Laser Cutting



- Possible restrictions with what we've looked at?
- All 2D? Flat-bed type laser cutting?
- Movie Clip of 3D Laser Cutting ([Weblink](#))

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