

Brunsfeld Basic Training Notes

General Rules and safety

1. Following the *completion of basic training*, students will be permitted to use the Brunsfeld Centre's workshop, and only those whom have already completed basic training will have access. Basic training will however grant limited access to the space as students will not have access to the mill, lathe, and welding area without having completed subsequent trainings for the respective equipment.
2. It is important to never work alone in the shop and to always have a supervisor on duty in the space. If working alone there is no one to help in the case of an accident or injury which makes it very dangerous.
3. Safety glasses must always be worn within the workshop. Safety glasses must be worn even if a face shield or welding helmet is being used overtop of them. Never approach anyone actively working the workshop without wearing safety glasses.
4. Proper footwear must be worn when working in the workshop to avoid hazardous situations (e.g. sparks, sharp metal, hot chips from operations) where the inappropriate footwear would cause greater levels of risk/harm. Closed-toed shoes must be worn. Not flip flops, crocs, mesh-toed running shoes or and similar style or type of footwear. Steel-toed or similar footwear is recommended when working on larger, heavier projects.
5. Clothing that is long, baggy and/or loose must be rolled up. Strings on the front of a hoodie and hanging jewelry must be tucked under a shirt or taken off. Rings must not be worn inside of the machine shop. Long hair must also be tied back and up. These rules are in place to avoid the danger of having machinery grab and pull you into them causing severe harm.
6. No food or drink should be brought into the workshop. There are many chemicals, coolants and other contaminants that can be harmful if ingested.
7. The Brunsfeld centre is a serious workspace and must be treated as one. Pranks, rough-housing, and general fooling around while within the workshop will not be tolerated. Any behavior deemed unprofessional and to this way by a supervisor will be met with an immediate suspension of shop privileges.
8. All persons within the MTC and Brunsfeld Centre must always be of good health both physically and mentally as well as not being under the influence of any drugs and or alcohol.
9. A first aid kit is located within the Brunsfeld office (Room A139). Any injury severe or small should be reported to a supervisor and an incident report should be

filled. In the case a supervisor is not present, contact the nearest designated first aider (a list of first aiders can be found on the main door).

- 10.** An emergency spill kit is available in the Brunsfield Centre. The spill kit can be used to clean and or contain hazardous materials that get spilled in the shop. A supervisor must be advised whenever the spill kit is used.
- 11.** There are fire extinguishers and emergency stops located throughout the Brunsfield Centre. There is one fire extinguisher located at each of the main entrance doors, and one near the designated welding area. There are three emergency stops located at the main entrances and in the office. Students should be familiar with the location of each fire extinguisher. If an individual is not familiar with these locations, they should request the information from a supervisor their first time in the workshop.
- 12.** Students are responsible for knowing their own limited knowledge of facilities and equipment, and to ask for assistance from a supervisor when encountering any unfamiliar equipment or processes (i.e. if you're not sure: Ask). Supervisors are there to help with any matter pertaining to the workshop and would much rather taking the time to explain something many times then having someone get injured or equipment break because of improper use of the space.
- 13.** Before working with unfamiliar materials and chemicals, become familiar with the product's handling procedures. MSDS (Material Safety Data Sheets) info can be obtained by using the Google search engine and typing "MSDS" followed by the product name and/or asking a supervisor to see the MSDS.
- 14.** Students as well as supervisors are entitled to a safe working environment. Safety is everyone's responsibility, thus anyone witnessing any unsafe behavior or working practices must advise a supervisor immediately.
- 15.** Any damaged equipment must be reported to a supervisor immediately to ensure shop safety and that the issue related to the equipment is correctly addressed. A supervisor must also be notified in the case of a broken tool to ensure that the tool was being used properly as to avoid the breakage of future tools.
- 16.** Students are responsible for keeping the workshop clean and tidy. It is required that students clean up any work areas or machines that have been used after you have finished. The floor must be kept free of debris and tripping hazards. All tools must be put back in their proper places after use. Unplug all power tools while not in use.

The Brunsfield Centre is a joint workspace for all students and a certain respect must be held for the space. It is important to treat the equipment and tools properly and with care so that everyone can have a better-quality work experience. The Brunsfield staff reserve the right to revoke shop privileges of anyone within the shop who does not respect the tools and equipment of the space as well as the rules listed above.

Notes

Drilling Operations - Cutting speeds

When performing any kind of machining process where you are removing material the speed at which you remove that material is of utmost importance. End mills, drill-bits and other cutter-based tools are only made to withstand certain cutting conditions. As such it is critical for the life of the tool and the efficiency of the machining process that the tools are run within their working parameters. When drilling with a standard twist-drill bit for example, the variables surrounding the operation are as follows.

The main variables to consider when drilling are:

- Desired Hole Size – Diameter and Depth
- The type of material – For specific properties and tool selection
- The coolant selected – Specific to the type of material and tool
- Machine and work-holding – Setup rigidity

Considering these factors, there is still a level of understanding that is required before the correct values can be found. This comes with experience, however there is a simple equation that may be used as a starting guideline for the correct rotation speed of the tool.

$$RPM = \frac{4 \times CS}{Dia.}$$

This starting formula takes into consideration the surface removal rate for a specific material/tool combination (denoted as **CS**) and the outmost cutting diameter of the tool (denoted as **Dia.**), and returns the recommended basic rotational speed of the tool (**RPM**). With a starting value an operator can begin the process and use their judgement to adjust the speed of the machine relative to the feedback encountered.

In general it is hard to list specific cutting speeds for each material in each situation. Some tools will contain information on their specific recommendations, however for general purpose work this is not usually obtainable. As a starting point, below are some recommended surface removal speeds which may be used in the general equation above.

Typical Values for SFM when using High Speed Steel (HSS) drill bits are:

Acier	80 SFM
Acier Inoxydable	40 SFM
Laiton	250 SFM
Aluminium	300 SFM
Plastiques	100 – 200 SFM

Examples

Drilling a 1/2" hole in Steel

CS (steel) = 80 SFPM
Drill Dia. = 1/2"

$$\begin{aligned}\text{RPM} &= 4 \times \text{CS} / \text{DIA.} \\ &= 4 \times 80 / .5 \\ &= 640 \text{ RPM}\end{aligned}$$

Drilling a 1/4 hole in Aluminium

CS (Aluminium) = 300SFPM
Drill Dia. = 1/4"

$$\begin{aligned}\text{RPM} &= 4 \times \text{CS} / \text{DIA} \\ &= 4 \times 300 / .25 \\ &= 4800 \text{ RPM}\end{aligned}$$

Since this equation provides only an approximate value for the maximum speed for a process, the feedback given from the tool and machine is the best source of understanding for what is happening (for good or for bad). The ability to interpret the feedback and the “feel” from a machine is what separates good machine operators from those with little to no experience. For example, a drilling process being performed at too high of an RPM will in some cases cause a lot of “chatter”. Chatter is the machining terminology for vibration. That is, chatter is used is because as the tool will vibrate a loud chatter-like noise. A drill bit undergoing a lot of chatter can be subjected to varying, dynamic loads on its cutting edges that may cause premature wear on the tool. Also yielding, in most cases, a poor surface finish or surface markings. When using machinery, it is extremely important to be constantly aware of the feedback and to adjust the way the operation is being performed accordingly. Audible feedback is one of the best forms for understanding how the machining process is performing. If something does not sound right, then there is a good possibility that the tool is not performing within its working parameters. This skill is developed over time and it is therefore recommended to always inquire with a supervisor before performing a machining process about the recommended cutting speeds and setup.

Drill Press

The Drill Press allows the operator to drill straight holes into a workpiece using a variety of different tools. The tools used in drilling operations are held in a three-jaw drill chuck and are rotated at high speed. With the workpiece clamped securely the hole drilled will be straight and not wander, if correct procedures are followed. This allows for a greater accuracy to be obtained than using a handheld power drill. The drill press can also apply a much greater force on the drill bit resulting in more consistent chip formation, and the ability to drill through hard materials such as steel with a greater ease.

Drill presses can come in both bench-top models and free-standing pedestal models. The model in the student shop is a pedestal model drill press shown in Figure 1. This allows a greater range of work heights to be accommodated. The drill press has a range of 12 speeds from 250 to 3000 RPM. Speed is set by changing belt positions on cluster pulleys. The cluster pulleys and the speed configuration diagram are shown in Figure 2.

The Drill Press can also perform other operations besides drilling but will not be covered in basic training. These processes include but are not limited to; reaming, countersinking, counterboring, and power tapping (with a reversing tapping head).

Parts



Figure 1: Pedestal Model Drill Press



Figure 2: Pedestal Model Drill Press Belt Casing

Safety Rules for the Use of the Drill Press

- 1.** Users operating any rotating machinery must not wear any rings, necklaces, neckties or wristwatches. Avoid loose clothing: if you have loose fitting sleeves, roll them up or cover them with a lab coat. Long hair must be tied back securely. Safety glasses must be worn at all times. Do not wear gloves, as they can get caught in the drill.
- 2.** Workpieces must be held securely to the table by clamps or bolts. Small pieces may be held in a drill press vice clamped to the table. Never attempt to drill a piece held by hand: the drill may grab and rotate the part, which can lead to serious injury to your hand. Long or heavy parts must be properly supported.
- 3.** Stand at all times when using the machine; never attempt to operate it from a sitting posture. Do not leave the drill running unattended.
- 4.** Be aware at all times of the location of the switch and emergency stop buttons and make sure that you can always reach them without obstruction.
- 5.** Emergency stops must be used only in emergencies. They must never be used to turn the machine on and off. If the emergency stop is used, make sure the drill press is turned off before pressing the start button on the panel.
- 6.** Never leave the chuck key in the drill chuck, even if you are not going to turn the machine on. Remove the key from the chuck before turning on the drill to avoid turning the chuck key into a very dangerous projectile.

7. Run the drill only at speeds suitable for the drill size and the material being drilled. This speed can be calculated using the equation shown in an earlier section. It is also important to use the proper lubricant when drilling, for a given material-tool combination.
8. Ensure that the **table height lock** and the **table swivel lock** (shown in Figure 1) are engaged before drilling.
9. When changing speeds and moving belt positions make sure that the drill press is unplugged from the wall or the breaker is shut off.
10. Do not touch the drill bit or other rotating parts when the drill is operating. If you have to clear chips from the bit use a wire brush. Never attempt to clear chips or oil using a wiper, it could easily get caught in the drill. Make sure that rags and swarf are kept away from the bit.
11. If you are drilling through a piece, make sure that you do not drill into the table. Position the hole in the table under the bit, or support the piece on a scrap of wood that can be drilled into.
12. Make sure that the chuck holds the drill tightly and concentrically. Do not allow the drill to jam and turn in the chuck, as this will damage the drill shank and potentially the drill chuck.
13. When drilling metal, start the hole with a centre punch first or a centre drill. Large holes are best drilled by starting with a small hole and enlarging it in steps, adjusting the speeds as needed.

Drill Bits

Most drill bits have two flutes, spiraling upward. The outer edges of these flutes have lands that cut the outer diameter of a hole. The end of the drill bit should have a distinctive chisel shown in Figure 3. The chisel-edge of a drill bit is used to cut work and push the material along the flutes of the drill bit. It is this cutting action that makes cutting into hard materials such as steel require such a large downward pressure while drilling. Drilling pilot holes (stepping up to the final size from a smaller size, incrementally) help the chisel get deeper into the material and push away the material with less required force.

Drill bits being long to be able to drill deep holes are very susceptible to bending forces. Some operations require a lot of force when drilling a hole into a new piece so that the chisel edge can grab into the piece and pierce its way forward. In this case the drill bit may begin to bend under the strain. This bending can cause a drill bit to break or to drill very inaccurate holes. This further shows necessity of drilling good pilot holes before using drill bits that require greater cutting forces.

The chisel edge, and the lip of the drill bit, should be equal and not worn or chipped along their edges. Damaged drill bit can cause excessive heat which can melt and damage drill bits. A damaged drill bit will also not drill clean accurate holes.

Drill bits used for copper and copper alloys as well as plastics require a different cutting geometry. The standard drills, when used with brass, bronze, copper, or plastics will tend to grab the piece which may cause harm to the user or damage the tool and equipment. Similarly, drills that have been ground for cutting brass will not effectively cut steel or aluminum.

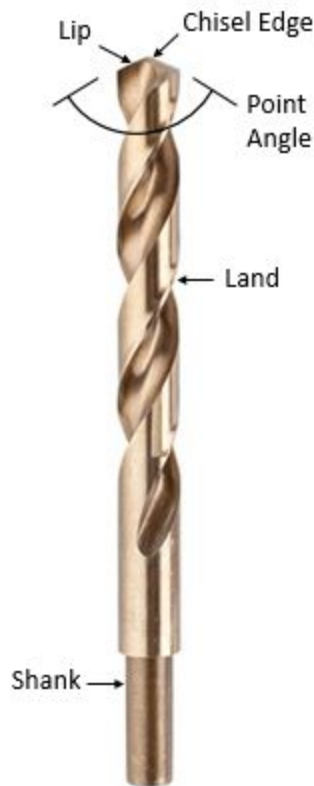


Figure 3: Twist Drill Bit

Clean Up Procedures

1. Clean up and return all drill bits to their proper place in the set that they belong to. Damaged and broken drill bits should be given to shop supervisor for repair and/or replacement.
2. Clean the table and drill press of chips and debris using a brush and dustpan or vacuum. Clean up surrounding floor if needed.
3. Be sure to unplug the machine after use.
4. Remove all clamping fixtures and vices but leave the vice grip clamp on the table. Ensure that the table height and swivel locks are engaged.
5. Remove any attachments (if used) and return the standard drill chuck to the spindle.
6. Report any problems with the drill press to shop supervisor.

Vertical Band Saw

A band saw utilizes a blade that is in shape of a continuous flexible loop which is driven around by two large diameter wheels. The size of a band saw is usually expressed as the diameter of the wheels. Some band saws may have a third wheel to give a larger throat to produce wider cuts. Band saws can be run at different speeds to accommodate a range of materials and surface cutting speeds which are usually indicated directly on the bandsaw. The relatively narrow width of the blades allows them to be used for contour cutting, meaning the bandsaw is not limited to straight cuts.

Bandsaws come in a variety of blade sizes as well as tooth pitches. It is important when using the bandsaw to not cut any material that is thinner than the thickness of three to five teeth. When the blade has only one to three teeth in contact with a piece at a time the teeth fall and impact the piece with a large dynamic load which can break off the teeth. When one tooth breaks on a bandsaw blade, the new empty spot causes the next tooth over to fall further before impact causing it to break and thus forms a cascading effect ruining the blade.

The bandsaws located in the MTC workshop have bimetal blades which that they can be used to cut wood and metals. However, the Bruntsfield centre is equipped with one bandsaw that cuts exclusively metals and another that cuts strictly wood.

Parts

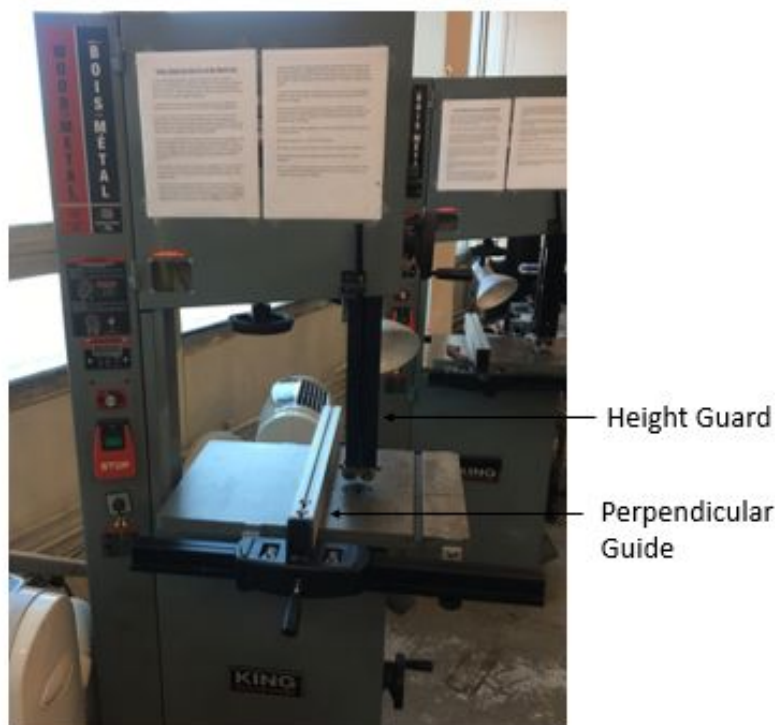


Figure 4: Vertical Bandsaw

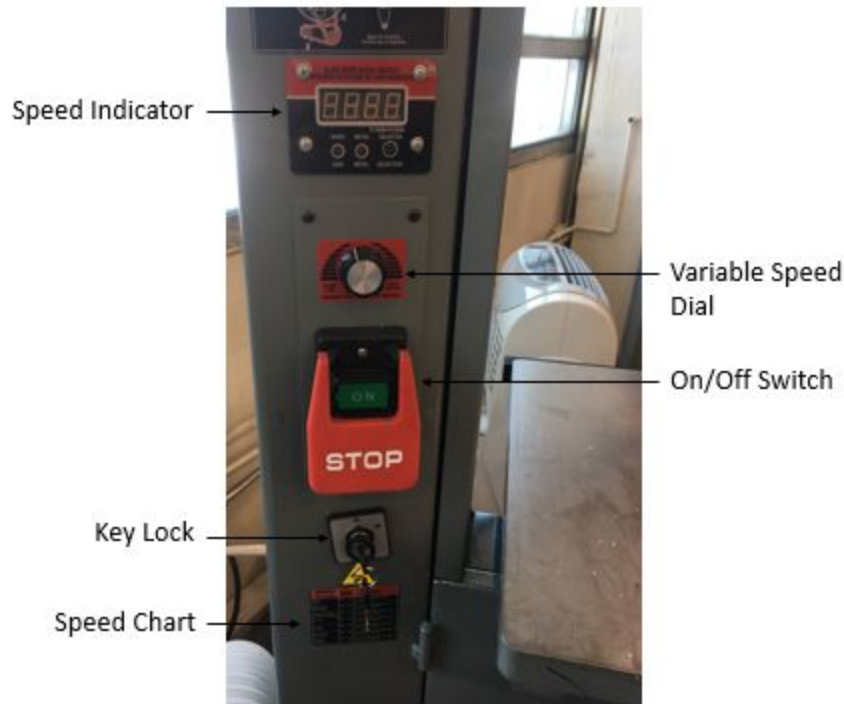


Figure 5: Vertical Bandsaw Control Panel

Safety Rules for the Use of the Band Saw

1. Users operating machinery must not wear any rings, necklaces, neckties or wristwatches. Avoid loose clothing: if you have loose fitting sleeves, roll them up or cover them with a lab coat. Long hair must be tied back securely. Safety glasses must be worn at all times. Do not wear gloves, as they can get caught in the blade.
2. Stand at all times when using the machine; do not ever attempt to operate it from a sitting posture. Do not leave it running unattended.
3. Keep your hands away from the blade at all times. Use the fence, mitre gauge, push sticks and other holding devices as necessary to guide and feed the piece into the blade. Be particularly careful to keep your fingers out of the blade path when breaking through the workpiece. Do not use rags near the blade or attempt to clean a moving blade.
4. Be aware at all times of the location of the switch and emergency stop buttons and make sure that you can always reach them easily.
5. Emergency stops must be used only in emergencies. They must never be used to turn the machine on and off. If the emergency stop is used, make sure the saw is turned off before pressing the start button on the contactor panel.
6. Run the saw only at speeds suitable for the material being cut, and make sure that the blade is the proper one for the material. A speed table is posted on the saw.

7. Inspect the blade before using the saw. Do not use worn or damaged blades, as they can break. If in doubt, ask the supervising technician to examine the blade. If a blade must be changed please consult with the supervising technician. Ensure that the blade is under the proper tension and that it is properly aligned in the guides.
8. Test the material to be sawn for hardness; a file should be able to mark the piece, and thickness; the material should be thick enough to be in contact with 3 to 5 teeth. Failure to meet these requirements will cause damage to the saw blade.
9. Ensure that all blade guards are in place and that the cabinet doors are closed and secure.
10. Set the guard to ½" above the workpiece.
11. Make sure that large or heavy workpieces are properly supported.
12. Lubricate the blade as required using the saw blade wax stick lubricant.
13. Turn off the power and unplug the machine when changing blades or adjusting parts of the saw. Do not ever open covers or guards when the saw is running.

Clean Up Procedures – Band Saw

1. Clean off the table and saw cabinet parts using the shop vac or a brush and dust pan.
2. Clean out the upper and lower cabinets.
3. Clean the surrounding floor area as required.
4. Put off-cuts into the garbage or recycle as appropriate.
5. Return accessories to storage cabinet as required.
6. Report any machine deficiencies to shop personnel.

Sheet Metal Manufacturing

Sheet metal work involves cutting and forming thin sheets of metal to form and fabricate metal parts. The capacity of the sheet metal working equipment in the shop is 16 gage steel (0.060") , 0.090" Aluminium, .040" Stainless Steel.

Treadle Shear

The treadle shear is used to cut sheet metal stock to size. The treadle shear is capable of cutting really wide pieces of sheet metal as well as small pieces. It uses a long metal blade that contacts with a hard metal backplate. When a piece is placed between the backplate and the blade the user can apply force onto the foot pedals in order to bring the blade down and shear the material along the metal backplate. A guide is located onto the table of the shear and can be used to keep the piece perpendicular to the blade giving a perfect square cut every time.

Parts

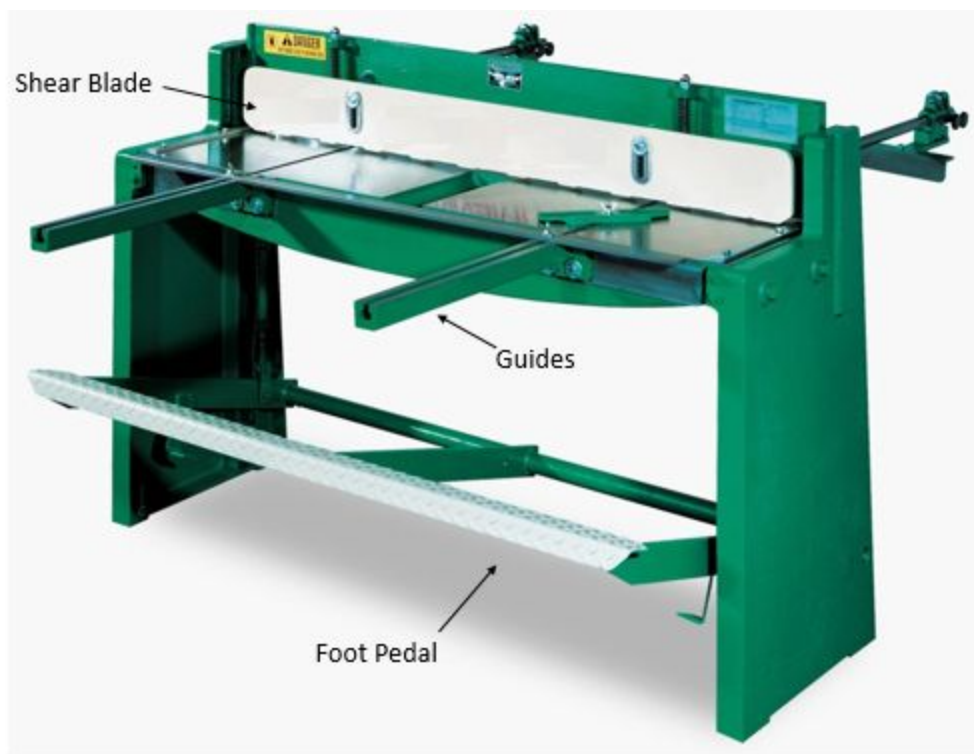


Figure 6: Treadle Shear

Safety

1. Stay within the capacity of the shear when cutting metal
2. Sheet metal edges can be sharp after cutting; avoid running fingers along them.
3. Ensure that the blade is not dull.
4. Ensure that the metal is clamped when cutting.
5. Keep fingers away from the blades when cutting.

Clean up Procedures

1. Remove scrap pieces and dispose of them in an appropriate manner

Layout Tools

Laying out parts in sheet metal is much like drafting only a scribe is used to mark the metal instead of a pencil. The main layout tools are; a scribe, a combination square. An automatic center punch may be used to mark punched or drilled holes after the initial layout is complete. Do not use the scribe as a punch; its tip will shatter.

Corner Notcher

The corner notcher is a shear that is designed to cut out the corners, a common operation when forming boxes. Its capacity is 4in and limit is 16 Gage steel. It uses a hand lever instead of a foot activated pedal like the treadle shear.

Parts

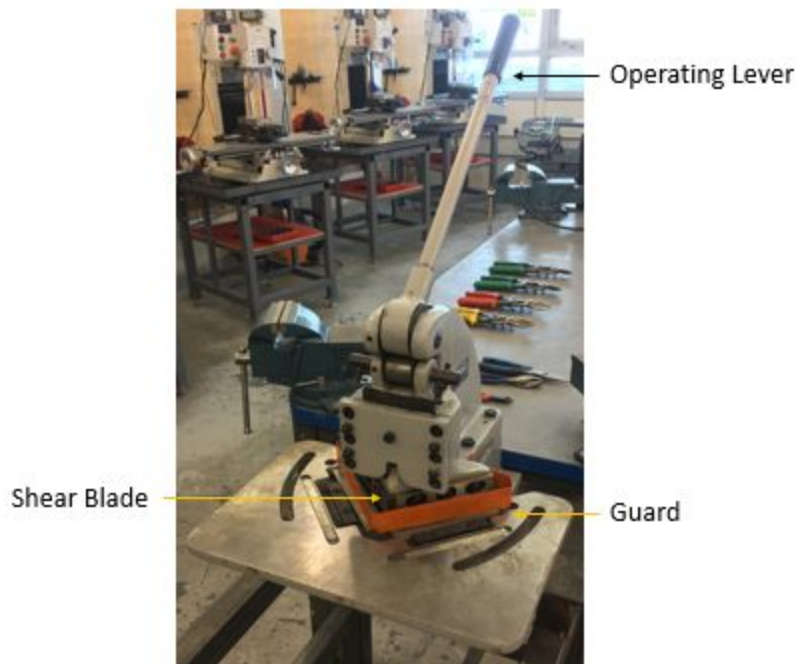


Figure 6: Corner Notcher

Safety

1. Do not exceed the capacity of the machine.
2. Do not leave the handle on the down position.
3. Ensure that the guides are clear of the blades when using.
4. Be mindful of your hand placement as the lever comes down to cut through the material so you don't cut yourself during the swing

Clean up Procedures

1. Remove scrap pieces and dispose of them in an appropriate manner
2. Leave the handle in a vertical position so that no one walks into it.

Hand Shear

The hand shear is used to cut sheet metal in lengths up to 6". It has a long lever, making it easier to use than snips but it is more difficult to do accurately.

Parts



Figure 7: Hand Shear

Safety

1. The capacity is 16 Gage steels
2. Do not cut wire.
3. If repeated cuts are done on the same edge, it can result in sharp slivers being created. Carefully remove these with a file to prevent cuts and other injuries.
4. Keep fingers away from the blade when cutting.
5. Leave the handle in a vertical position so that no one walks into it.

Clean up Procedures

1. Remove scrap pieces and dispose of them in an appropriate manner

Snips



Figure 8: Tin Snips

The type of snips in the student shop are **aviation snips**, also known as tin snips. These snips come in three varieties and have colour coded handles to identify them. They are designed to cut tight corners or radius cuts. All of them can do left and right-hand cuts but the Red – handled and the Green –handled ones can do tighter corners in the left and right-hand direction respectively. The Yellow-handled (straight) snips can do right and left radius cuts equally well but neither as tight as the Red- handled or the Green-handled ones in their respective directions. The limit on the gage of metal that can be cut is about 20 gage steels, but the initial limit depends on the hand strength of the operator. Many will initially find that this will be about 22 Gage steels (0.030”)

Safety

1. Sharp slivers can be created along continuous cuts if not done precisely. These must be carefully removed to avoid cuts.
2. The blades must be roughly perpendicular to the sheet, when cutting, to cut properly.

Box and Pan Brake

A sheet metal brake is a machine used to bend sheet metal along a bend line. A brake can fold an angle up to 120° in sheet metal. This machine is used to bend the sides for boxes, pans and other forms. A brake can only bend opposite sides due to clearances. A Box and Pan is a variation on the basic brake that has removable and repositionable fingers that allow adjacent sides to be folded. The gaps between the fingers provide a clearance space for an adjacent side of a box or pan to swing into during bending.

Parts



Figure 9: Box and Pan Brake

Safety

1. Use caution when handling sheet metal. Check for sharp edges and remove them.
2. Do not try to bend sheet metal beyond the capacity of the machine.
3. Keep fingers out of the mechanism.

Clean up procedures.

1. Replace all removed fingers.
2. Do not leave any metal in the brake.
3. Dispose of any practice or set up pieces as necessary.

Spot Welding (RSP)

Spot Welding or Resistance Spot Welding is a simple welding process for sheet metal. The idea is that the two pieces wanting to be welded together are held and clamped between two electrodes. A large current is then passed between the two electrodes, and due to the resistance of the electrical current within the material the area between the two electrodes heats up and fuses together. Different thicknesses of materials require more, or less, heat to create a spot weld. However, the amperage outputted by the machine is constant. Therefore, the amount of time the current is passed between the two electrodes is controlled and adjusted depending on the thickness of material.

This process does not require any shielding gas, flux or filler material. It is a fast process and is used a lot in the industry. The spot welder used for the lab requires only the setting of the weld time and occasional cleaning of the electrodes. Contact pressure can be adjusted but with steel a wide range of pressures can be used so it is often not required to adjust the pressure.

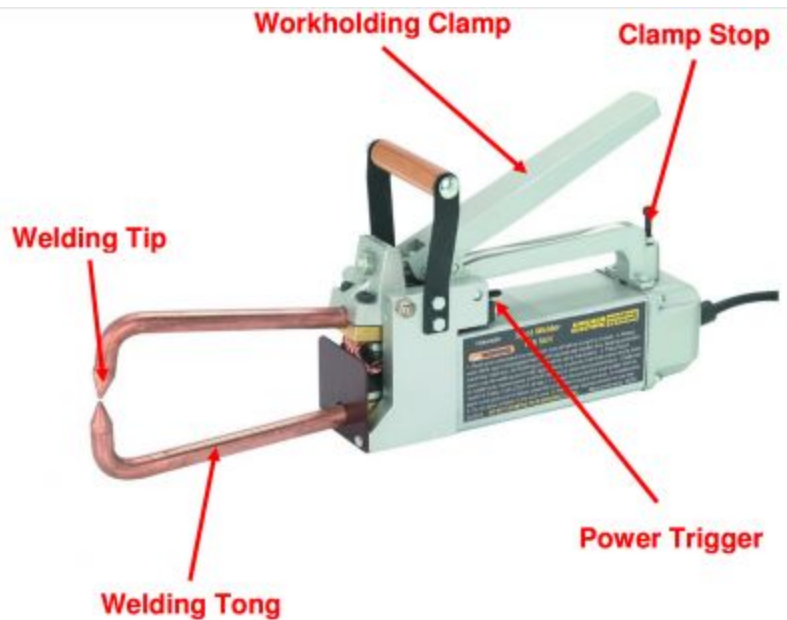


Figure 10: Spot Welder

Safety

1. Ensure that the metal being spot welded is clean and free of grease.
2. The electrodes contact area must have through electrical conductivity.
3. The spot welding process produces sparks and high temperatures. Therefore, the appropriate PPE must be worn; safety glasses, non-synthetic clothing, closed, footwear, welding gloves, and a welding beanie.
4. Ensure that the electrodes are clean before using.
5. Ensure that larger pieces are adequately supported.
6. When finished pull the electrodes fully onto the bench so that they are out of traffic.

Clean up Procedures

1. Turn the welder off.
2. Unplug the welder.
3. Pull the electrodes back to be fully on the bench.
4. Clean the electrode tips with a file if needed.