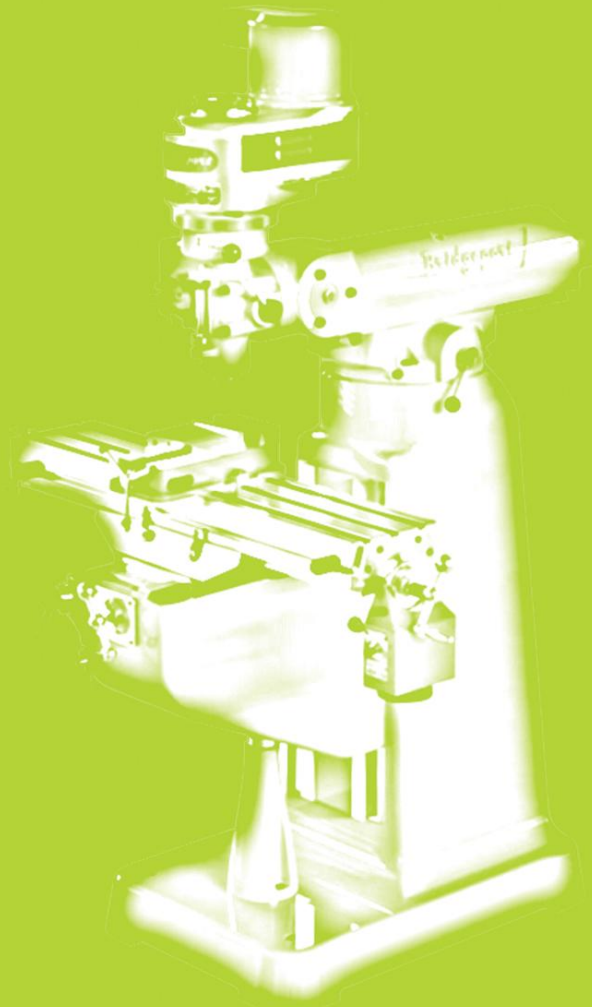


BRIDGEPORT MILLING MACHINE CERTIFICATION TUTORIAL



MAKER WEB

TUTORIAL OVERVIEW

This tutorial will give you a basic understanding on how to operate the Bridgeport Milling Machine in the Make Lab.

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Part 1:

Tutorial Description

DESCRIPTION

Milling machines are very versatile. They are usually used to machine flat surfaces on square or rectangular parts, but can also produce many unique and irregular surfaces. They can also be used to drill, bore, and produce slots, pockets and many other shapes. The type of milling machine in the Maker Web Lab is a variable speed vertical spindle, knee-mill with a swiveling head (also known as a “Bridgeport”).

Although there are several other types of milling machines, this document will focus only on the vertical milling machine. A milling machine removes metal by rotating a multi-toothed cutter that is fed into the moving workpiece. The spindle can be fed up and down with a quill handle on the head or by moving the Knee up and down.

This process of separating the work piece (the part you want to produce) from the “chips” (the unwanted material surrounding the part you want to produce) requires 5 things.

- A securely held, sharp tool
- A securely held workpiece
- Sufficient force applied to the tool to produce chip separation
- The continuous removal of newly formed chips (allowing the formation of subsequent chips)
- The prevention of overheating of the tool and / or work piece

The goal of this document and the accompanying training is not to make you an expert mill operator or machinist, but to make sure you can safely do certain basic tasks. It applies to all students, staff, faculty and others who wish to use the machine shop. This document should be read, fully understood, and reviewed at the machine with a Maker Web employee as part of the certification process.

- Certification is required to use the Bridgeport Milling Machine. In order to get certified you must:
- Review this document at the machine with a Maker Web Employee.
- Demonstrate “hands-on” proficiency with a Maker Web Employee by milling a piece of aluminum.
- Sign the BASIC USER CLEARANCE FORM, WAIVER and SUPERVISED EXPERIENCE LOG.

The allowable machining tasks will be limited to those covered in this document. There is much more to using a mill than what is covered in this document so always ask a Maker Web employee before doing any task not mentioned in this document.

Part 2:

Learning Objectives

HOW TO USE THIS DOCUMENT

As stated, the goal of this document is to give you a basic ability to safely operate the Bridgeport Milling Machine. There are several parts to the document and several learning objectives. It is recommended that you start by reading the document on your own in or out of the Shop. It is then mandatory to go through the document again, step by step, while actually engaging the machine with a Maker Web employee.

LEARNING OBJECTIVES

While going through this document while engaging the machine it will be required that you go through the following steps and complete the following tasks that correspond with the sequential “Parts” of the tutorial.

- REVIEW DOCUMENTATION
- IDENTIFY ALL PARTS OF THE MACHINE
- CLAMPING AND FIXTURING THE WORK PIECE
- POWERING ON THE MACHINE
- SETTING RPM VALUES
- MOVING AND LOCKING THE XYZ AXIS
- MOVING AND LOCKING THE QUILL
- CUTTING TOOL BASICS
- MILLING OPERATIONS AND CUT TYPES
- INSTALLING AND REMOVING CUTTING TOOLS
- USING THE DRO TO ZERO A WORK PIECE
- CUTTING FLUID
- DEPTH OF CUT
- CUTTING SPEED

Part 3:

General Rules

- You must wear safety glasses AT ALL TIMES while in the shop area. You must wear safety goggles over prescription glasses. A full face shield may be recommended for some operations. Hearing protection is recommended.
- You will remove all loose rings, watches, necklaces, bracelets, and dangling earrings before operating the Milling Machine. Loose or dangling objects can easily become caught in rotating machinery.
- Long pants are recommended. Keep hair, clothes, hands, and loose tools away from moving machinery. Loose hair and clothing are extremely dangerous. You must tuck in your shirt, roll up long sleeves, secure drawstrings, tie back hair, etc...
- No open toe shoes allowed in the Lab. Shoes must be fully enclosed. Inappropriate footwear includes: open toe shoes, sandals, crocks, high heels, etc...
- Know the location and proper use of the nearest fire extinguisher, first aid kit, eyewash station, and other emergency supplies.
- Anyone using the Milling Machine should be accompanied by another person who can assist, render first aid, or contact emergency services in the event of an emergency.
- Do not wear gloves while operating power tools or machines. Like jewelry, they can easily be caught in rotating machinery.
- Every tool in the machine shop has the potential to cause serious injury or death. Horseplay, pranks, and improper use of equipment are forbidden without exception. Anyone who witnesses another person using equipment in an unsafe or improper manner has the right to give advice on safe and proper usage. Refer to this document if necessary.
- Refrain from any action that may surprise someone who is currently operating equipment, including shouting, dropping heavy objects, touching the member, or standing too close to them. Surprising people may cause serious or fatal injury.
- Only one person may operate a tool at a time. Do not interfere with anyone else's operation. Do not distract anyone who is operating equipment. Avoid talking with anyone while operating a machine tool. Keep your mind on the job and be ready for any emergency!
- Become thoroughly familiar with the milling machine before attempting to operate it. When in doubt, obtain additional instructions.

Part 3:

General Rules (continued)

- Check equipment for mechanical issues or pressing maintenance needs before turning it on. If you notice an issue with the equipment, report it to an employee immediately. If the machine makes an unusual noise or acts in any suspicious manner, you must stop the machine and inform the instructor immediately.
- Turn off equipment when you are done using it. Do not leave unattended machines running!
- Before leaving the shop area, you must assist in cleaning any mess (metal chips, splashed coolant) that you produce. You must clean any spilled liquids immediately. Leave the machine and surrounding area at least as clean as you found it.
- Use a vacuum cleaner or a brush and dustpan to clean up. Do not attempt to clear swarf with your bare hands or compressed air. Most metal cuttings will be sharp or hot. STOP the machine before trying to remove accumulated chips.
- You will return any tools, instruments, bits, etc. to their proper location after using them.
- You must immediately report ANY injury to an employee. If an injury requires medical attention, call 911 immediately.

COMPETENCY:

General Rules



ACTION ITEM:

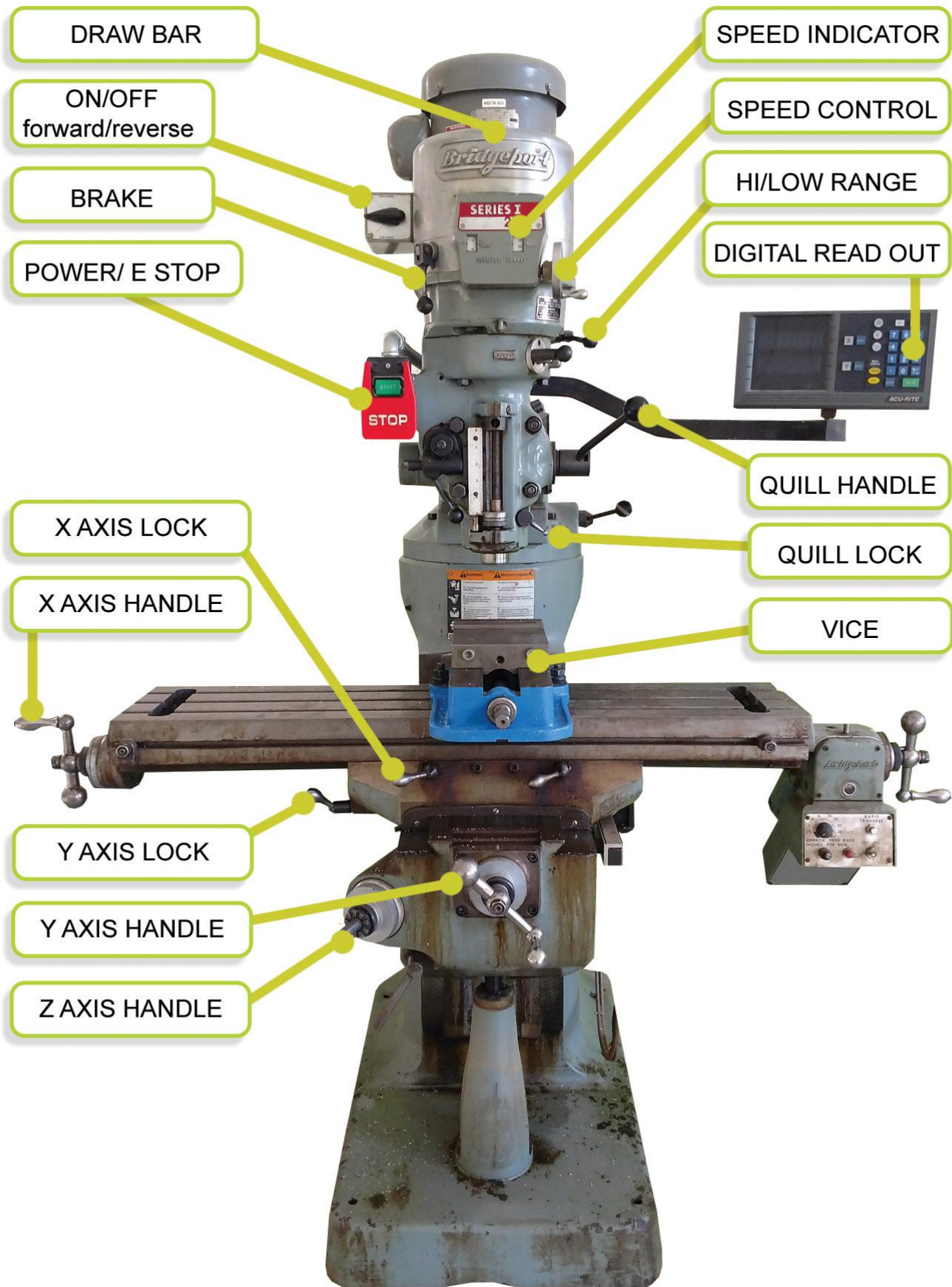
ASK THE STUDENT QUESTIONS

QUESTIONS:

- Have you read the rules thoroughly?
- Do you understand the rules completely?
- Do you have any questions about the rules?

Part 5:

Operational Machine Parts



Part 6:

Operational Machine Parts Description

Drawbar-For inserting or removing of collets / cutters from the machine spindle.

On/Off Forward/Reverse-a motor reversing switch. When the attachment is in (HIGH SPEED), the motor and spindle are turning in a clockwise direction as viewed from the top of machine. When the attachment is in (LOW SPEED), the spindle will run backwards (counter-clockwise) unless the motor direction is reversed by switching the *Hi Low Range Switch* to “Low”. The switch is marked Hi-Lo. This will indicate the proper switch position. They should be positioned alike or the spindle will run backwards. - NOTE - Spindle should run in clockwise position.

Brake-For manually stopping the rotation of the spindle after turning the spindle off.

Power/E Stop-The green button turns on power the machine and the red paddle is the emergency stop to shut down the machine.

X Axis Lock-tightening these locks the X Axis in place.

X Axis Handle- For moving the machine table in the X+ or X- direction (left or right)

Y Axis Lock-Tightening these will lock the Y Axis in place.

Y Axis Handle- For moving the machine table in the Y+ or Y- direction (front to back)

Z Axis Handle- For moving the machine table in the Z+ or Z- direction (up and down)

Vice-For clamping work pieces onto the milling machine table.

Quill Lock-For locking the machine's quill at a preset height or location.

Quill Handle-For moving the quill up and down in the Z-axis direction.

Digital Read Out-A digital measuring device that locates the spindle relative to the workpiece.

Hi/Low Range-Used to coordinate with the On/Off Direction Nob to choose Hi and Low RPM ranges that can then be controlled with the Speed Control dial. The middle position is the neutral position. Never move the spindle reverse lever when the spindle is turning.

Speed Control-For adjusting the spindle rotation speed (RPM).

Speed Indicator-Shows the selected spindle speed.

COMPETENCY:
Machine Description



ACTION ITEM:

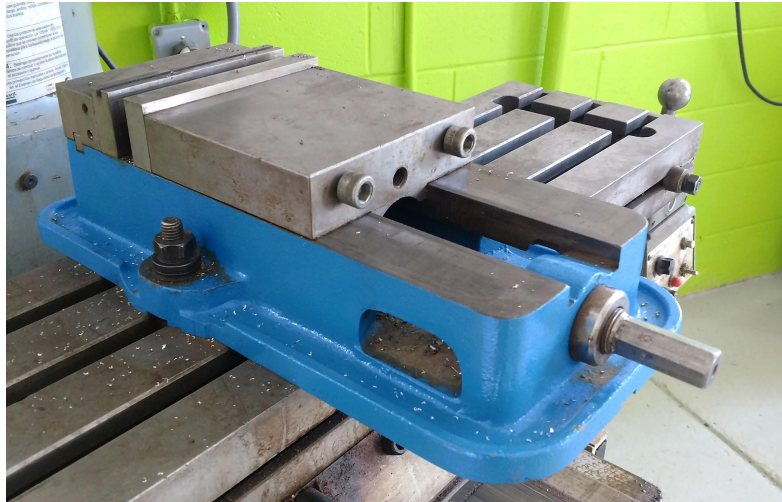
ASK THE STUDENT QUESTIONS

QUESTIONS:

- Can the student identify all of the critical parts of the machine?
- Does the student see how to turn on the machine?
- Does the student see how to change the direction of the spindle?
- Does the student see how to change the RPMs on the spindle?
- Does the student see how to move the XYZ axis?
- Does the student see how to lock the XYZ axis?

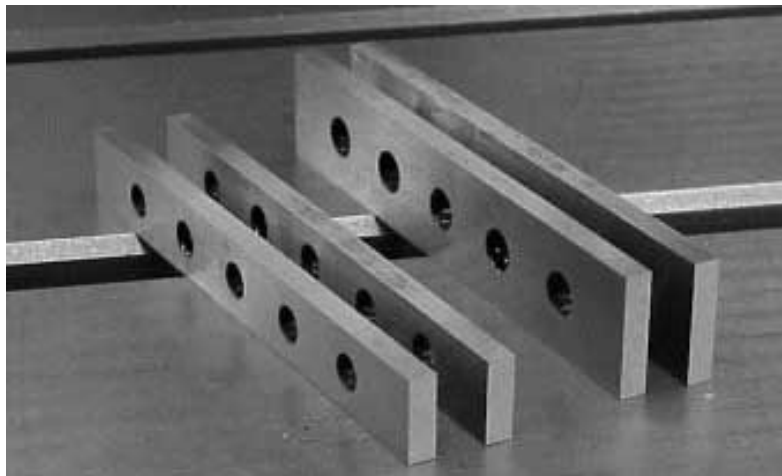
Part 6:

The Vice and Clamping a Workpiece



GENERAL CLAMPING TIPS

- A. ALWAYS SHUT OFF THE MACHINE BEFORE DOING ANYTHING IN OR NEAR A VICE.
- B. Don't assume the vice is aligned or tightened down! Always check it's stability.
- C. Always wipe off the vice jaws, parallels and other fixtures when clamping a new part.
- D. Always grip at least 50% of the part and in the center of the jaws.
- E. Never grip a part at just one end of the vice, unless an identical part is at the other end.
- F. Get instruction or supervision if you are unsure of how to use the vice
- G. Turn the handle (not shown) clockwise to tighten and counterclockwise to loosen. Remove handle when not in use

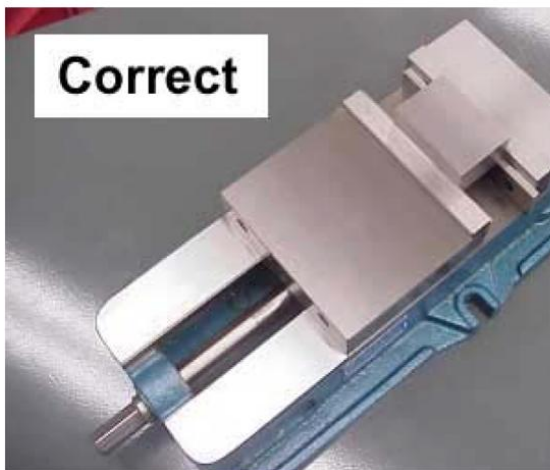


USING PARALLELS

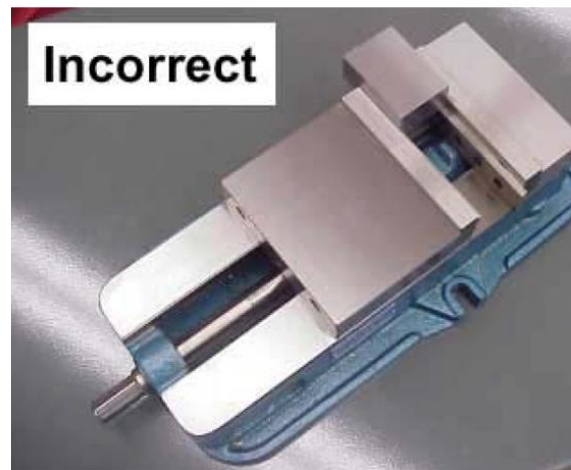
Parallels are used to raise the work above the vice jaws for machining, drilling or other operations. They can set the part height so the vice jaws will not be hit by your cutting tools and that any drilling operations will not cut into the bottom of the vice. Make sure you use a matching (height) set. Also be aware of running into the parallels, and constantly check to see that they have not moved unintentionally. It is a good idea to always check that no chips have fallen on top of or underneath the parallels, as this will greatly affect the accuracy of your parts!

Part 6:

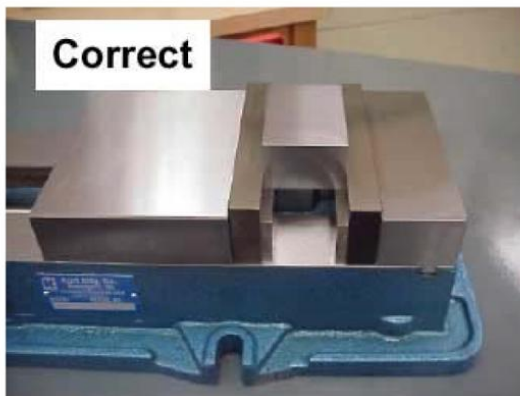
The Vice and Clamping a Workpiece



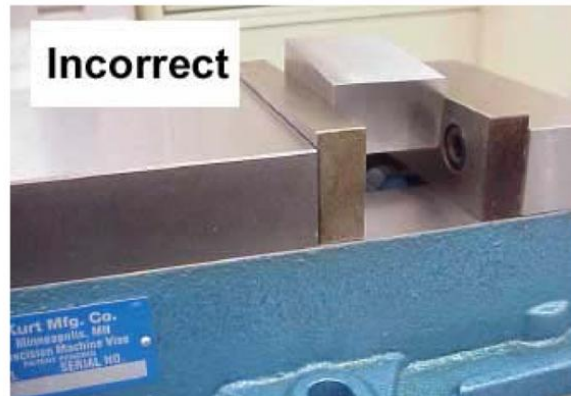
Locate the part in the center of the vise. This equalizes the pressure on the vise jaws.



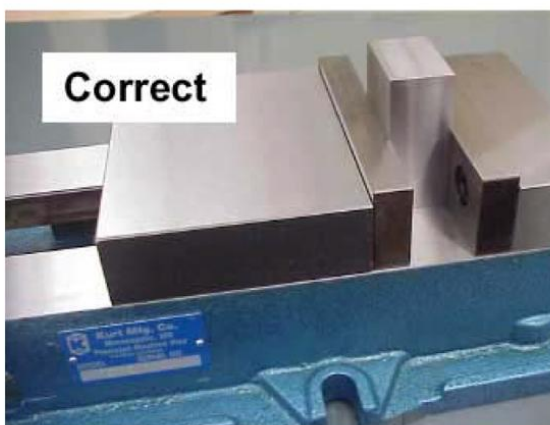
Holding the workpiece off center puts unequal pressure on the vise jaws. This can cause the piece to loosen up.



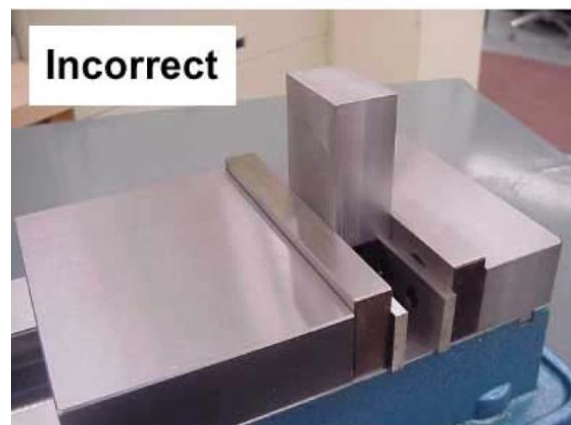
The workpiece should always be supported by the bottom of the vise or by parallels.



Work pieces that are not supported will move under the pressure of the cutting forces.



Keep the workpiece as low in the vise as possible.



Work that extends out of the vise has a greater chance of loosening up under cutting conditions.

COMPETENCY:

Using The Vice and Clamping a Workpiece



ACTION ITEM:

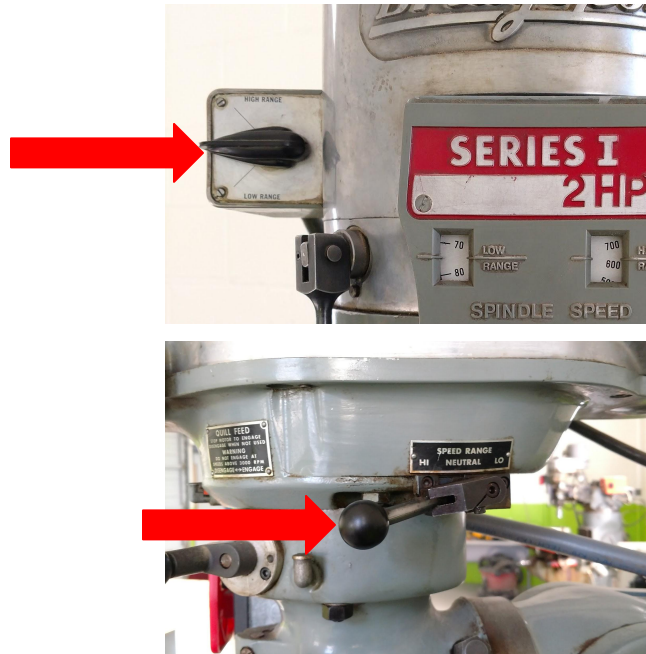
HAVE THE STUDENT USE THE VICE TO HOLD A PIECE OF ALUMINUM STOCK

QUESTIONS:

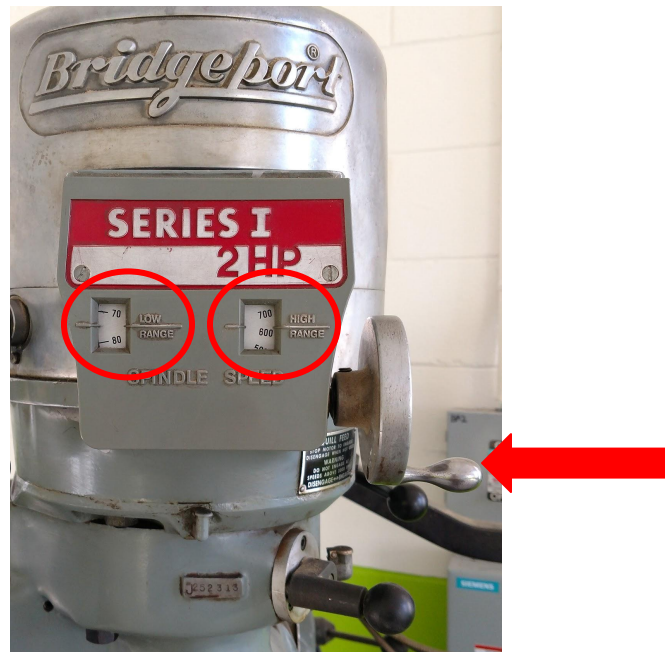
- Did the student clean the vice and the parallels before use?
- Did the student place the workpiece in the center of the vice?
- Did the student place the workpiece sufficiently deep in the vice?
- Did the student use the parallels correctly?
- Is workpiece held in place firmly so that it will NOT MOVE?

Part 9:

Setting Spindle RPM Values



With the machine turned off, turn Clutch knob on the left to the desired HIGH or LOW range. Set the HI/LOW knob on the right to match. You may need to jiggle the spindle a bit to make sure the HI/LOW knob is properly in gear. **NEVER** change the HI/LOW setting on the right while the machine is running. To change the range: Power down the machine by hitting the STOP button. Let the Spindle come to a complete stop. turn the Forward/Reverse knob to desired range, then adjust the HI/LOW range to match.



Once you are in the proper range and the spindle is spinning, you can use the RPM dial to fine tune the speed. **Adjusting the RPM dial can only be done while the spindle is spinning.**

COMPETENCY:

Moving and Locking the XYZ Axis and the Quill



ACTION ITEM:

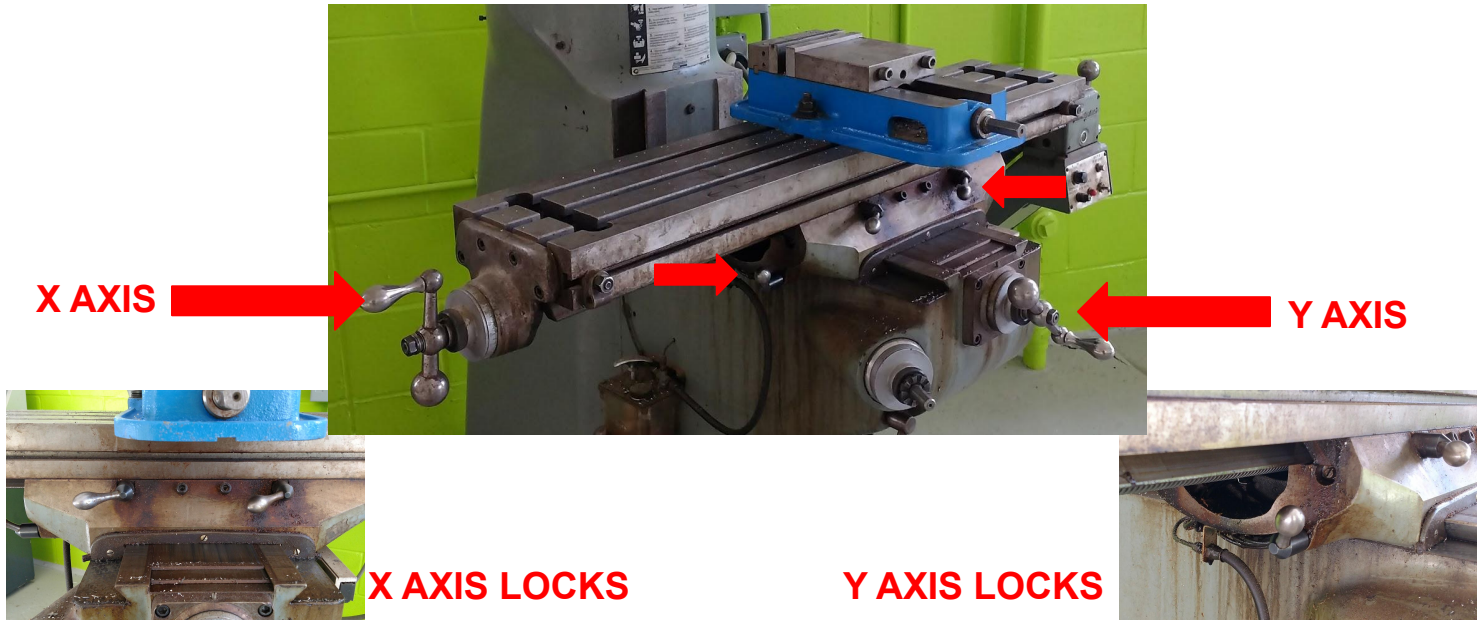
**SELECT A SPINDLE RPM SPEED AND HAVE THE STUDENT
ADJUST THE MACHINE TO THAT SPEED. REPEAT THIS AT LEAST
ONCE.**

QUESTIONS:

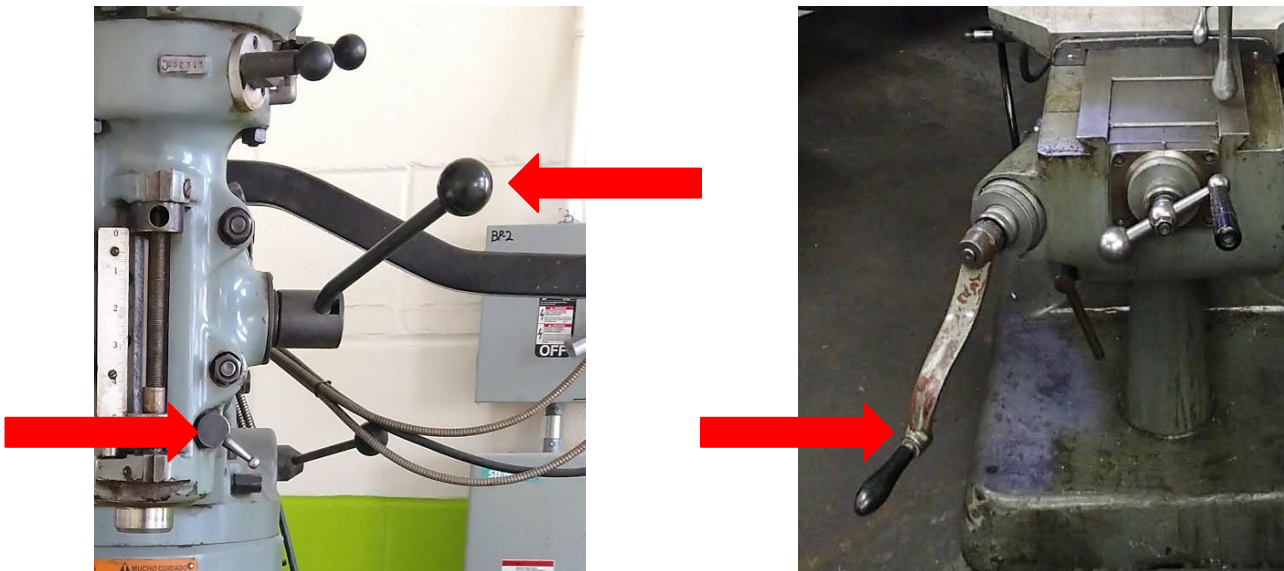
- Did the student check to be sure they selected the proper Hi/Low Forward/Reverse range and that the Hi/Low range on the right of the machine matched before turning on the spindle?
- Did the student jiggle the spindle by hand while adjusting the Hi/Low range on the right to be sure the spindle is engaging the gears.
- Did the student turn on the spindle and adjust the speed using the dial?
- Does the student understand not to use the Hi/Low range on the right while the spindle is moving.

Part 8:

Moving and Locking the XYZ Axis and the Quill



To move the X Axis (right and Left) turn the knob on the left end of the table. There is a corresponding knob on the right end of the table that does the same thing. You can Lock the X Axis by tightening the 2 set screws on the front of the table. To move the Y Axis (forward and backward) turn the knob on the front of the machine. To lock the Y Axis tighten the set screw on the left under the table. All of the knobs have measurement dials that can be used in addition to the DRO. The dials increments are .001".



Use the Quill Handle on the right to move the Quill up and down and use the Quill Lock lever to lock it in place. Next use the Z axis handle to move the knee vertically. Note that you will often have to put the handle on the crank as it is taken off during use. Note the dial gauge on the handle that allows you to move the knee very precisely. Most often you would lock the Quill in place and use the Z axis handle to control the Z axis movements.

COMPETENCY:

Moving and Locking the XYZ Axis and the Quill



ACTION ITEM:

HAVE THE STUDENT MOVE/LOCK THE X,Y,Z AXIS AND THE QUILL

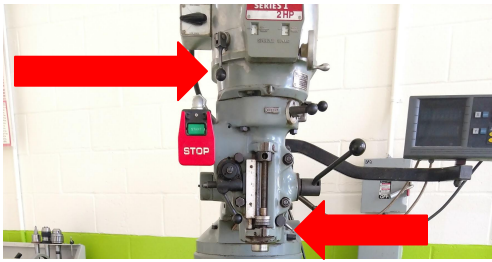
QUESTIONS:

- Does the student understand how to move the XYZ Axis?
- Does the student understand how to lock the XYZ axis?
- Does the student understand how to use the dial indicators on the different axis?
- Does the student understand how to move the quill up and down?
- Does the student understand how to lock the quill?

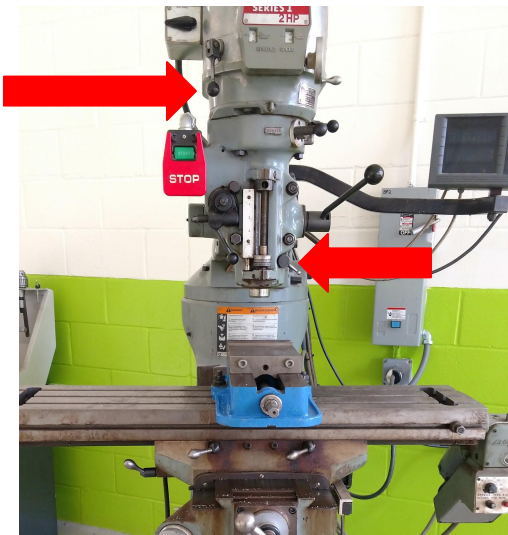
Part 10:

Installing and Removing Cutting Tools

REMOVING OR INSTALLING CUTTING TOOLS IS ALWAYS DONE WITH THE MACHINE OFF!!! Make sure that there is enough room between the quill and workpiece/vice/table (8"-12")



To remove a tool from a machine, move the quill to the highest position and lock it in place with the quill lock. Engage the spindle break so it cannot spin. Place the Drawbar Wrench on the Drawbar on the top of the milling head. Hold whatever is in the collet (endmill, drill chuck, etc.) If you do not hold on to the collet and cutter, they will fall and can be damaged. Turn the wrench counterclockwise to loosen it. You will feel the spindle loosening and opening. This will release the collet and cutter from the spindle. Do not fully loosen the Drawbar. To get the collet and cutter free you may need to tap the Drawbar with a rubber mallet.



In order to install a collet and cutter, move the quill to the highest position and lock it in place with the quill lock. Engage the spindle break so it cannot spin. Place the desired milling cutter (or drill chuck) in a collet of the correct diameter. Insert the bit as far as possible but make sure there is no less than 1/8" from the top of the flutes to the collet. Insert the collet into the spindle. Ensure that the key way on the collet mates properly with the key in the spindle and the collet is fully inserted. Place the Drawbar Wrench on the Drawbar on the top of the milling head. While holding the tool with one hand, turn the wrench clockwise to tighten it. Give the wrench a final twist to be sure the collet and cutter are tightly held in place. Disengage the spindle break before turning the machine on.

COMPETENCY:

Installing and Removing Cutting Tools



ACTION ITEM:

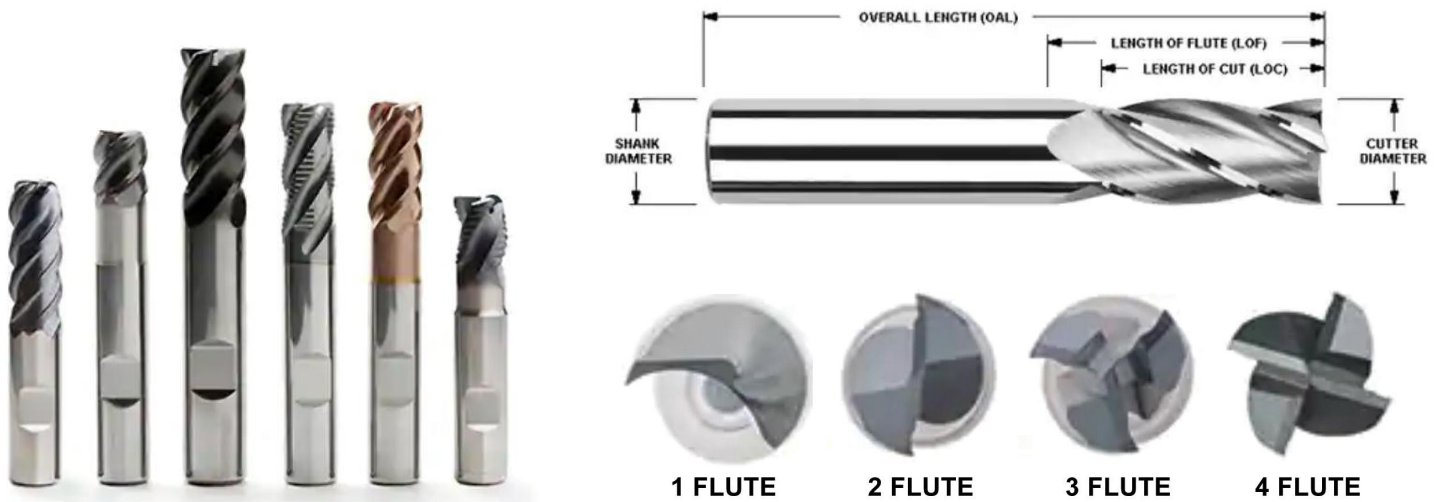
HAVE THE STUDENT INSTALL AND REMOVE A CUTTING TOOL

QUESTIONS:

- Did the student check that the machine was turned off before attempting to change the cutting tool or engage the spindle?
- Did the student make sure they selected the correct diameter collet for the selected cutting tool?
- Did the student insert the bit as far as possible and leave no less than 1/8" from the top of the flutes to the collet?
- Did the student ensure that the key way on the collet mated properly with the key in the spindle?
- Did the student make sure NOT to fully unthread the drawbar when loosening and make sure to tighten snugly but not over tighten when inserting a tool?

Part 11:

Cutting Tool Basics



End mills are the most common milling cutters. End mills are available in a wide variety of lengths, diameters, and types. A square end mill is used for most general milling applications. It produces a sharp edge at the bottom of pockets and slots. For fast cuts and the greatest rigidity, use shorter end mills with larger diameters. Variable helix end mills reduce chatter and vibration. Use cobalt, PM/Plus and carbide on harder materials and high production applications. Apply coatings for higher feeds, speeds and tool life



Collets are used to hold the tool in the Spindle. Always use the correct size collet for the cutter diameter.

COMPETENCY:
Cutting Tool Basics



ACTION ITEM:

ASK STUDENT QUESTIONS

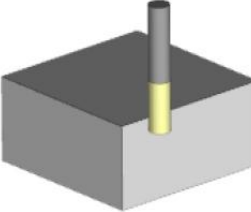
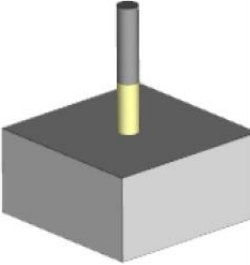
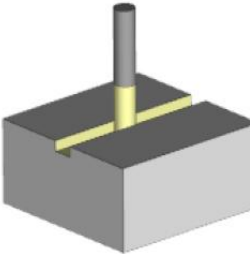
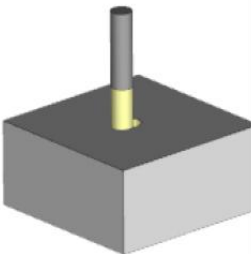
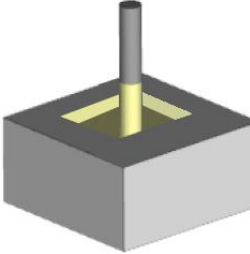
QUESTIONS:

- Do understand how to identify various bits?
- What are three most important ways you can identify bits?

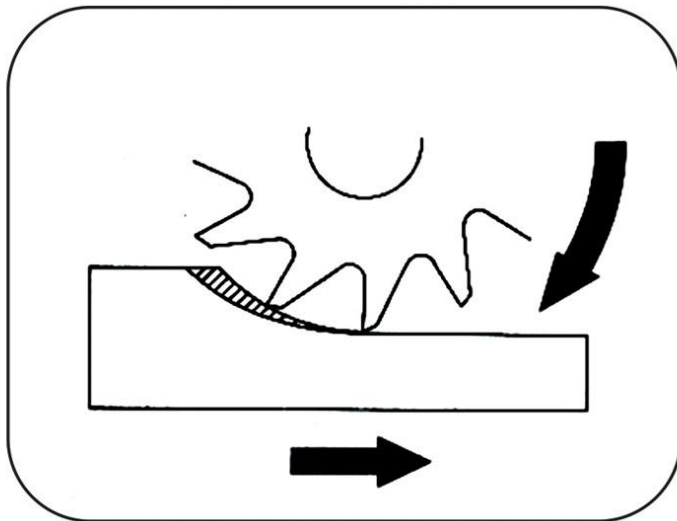
Part 12:

MILLING OPERATIONS AND CUTTING TYPES

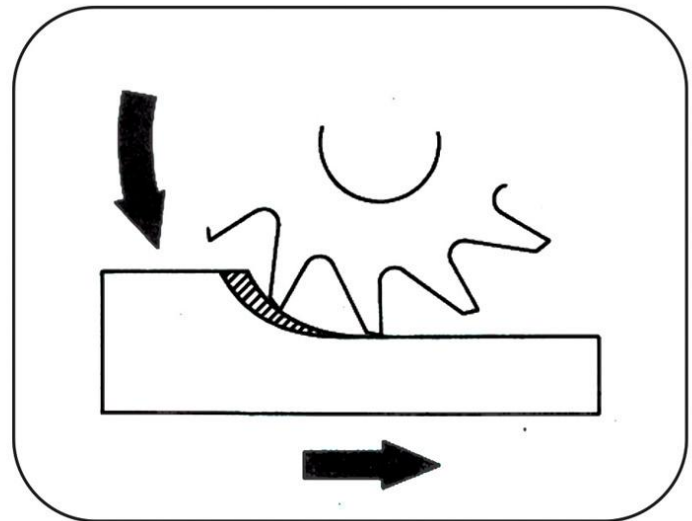
Applications for End Mills

Side Milling	Face Milling	Slot Milling	Plunge Milling	Pocket Milling
				
Machining of an edge surface on the part.	Machining of a top face on the part.	Machining linearly between two points.	Axial feeding into a part along the Z axis.	Axial feeding along the X and Y axis to remove a region of material

These are the most common milling operations and will and will be the majority of the work done on the machine. They are Side Milling, Face Milling, Slot Milling, Plunge Milling (drilling), and Pocketing. These are the only milling types allowed on the Bridgeport machine.



CONVENTIONAL CUTTING



CLIMB CUTTING

When milling, one should be aware of the difference between conventional, and climb milling. In conventional milling, the workpiece is fed into the rotation of the cutter. This type of cut requires lower forces and is preferred for roughing cuts. In climb milling, the work moves with the rotation of the cutter. This produces a better finish. It is not recommended if the workpiece cannot be held securely or cannot support high forces.

COMPETENCY:

MILLING OPERATIONS AND CUTTING TYPES



ACTION ITEM:

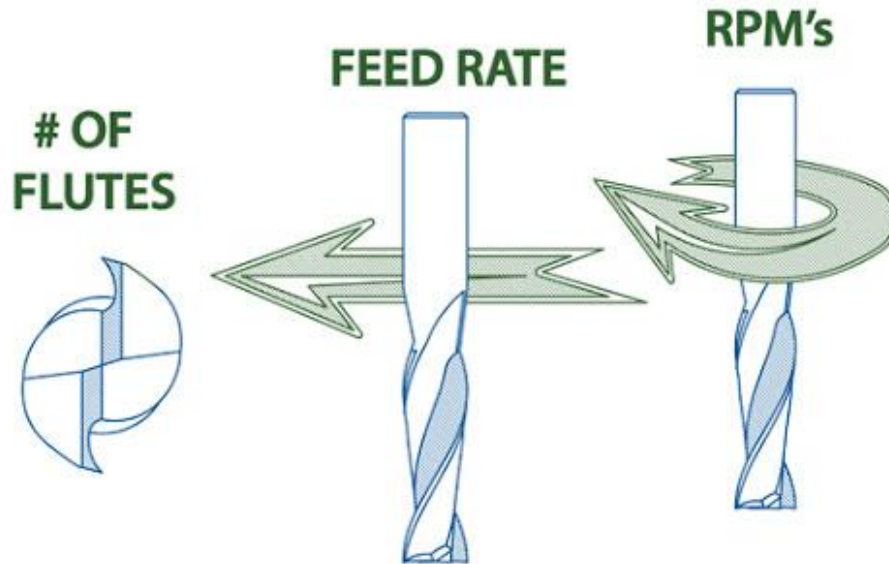
ASK STUDENT QUESTIONS

QUESTIONS:

- Do you understand the 5 basic milling operations allowed on the machine?
- Do you understand the difference between conventional and climb milling?

Part 13:

Feeds and Speeds and Depth of Cut



“Speed” refers to the spindle RPM (Revolutions Per Minute). “Feed” or feed rate refers to the the speed of the cutting tool moving across or into your workpiece. Feeds and speeds affect the time to finish a cut, tool life and cut quality finish of the machined surface and power required of the machine. The cutting speed is mostly determined by the material to be cut and the material of the cutter. A happy machine is a quiet machine. Using improper feeds and speeds can be dangerous and care should be taken.

SPEED VS. FEED - BASIC GUIDELINES

You **INCREASE** the **FEED RATE** too much... You risk taking too big a “bite” and will break the cutter.

You **DECREASE** the **FEED RATE** too much... You risk “rubbing” (not cutting) and will wear out the cutter.

You **INCREASE** the **SPINDLE SPEED** too much... You will not cut, but instead burn up the tool with friction.

You **DECREASE** the **SPINDLE SPEED** too much... Your cut will be very slow.

You find the right balance The machine will be quiet (not screaming or shaking)

You find the right balance You will be making (nice, not discolored) chips.

You find the right balance You will be removing material and the cutter will last!

Lubricant plays a critical role in cutting. Make sure you use plenty of lubricant while cutting. To find the right speed for any task, start with an RPM of 800 and a cut depth of .050”. Cut slowly and note the sound the vibrations and the chip quality. Tune feeds and speeds and cut depths accordingly. The feed rate depends on the width and depth of cut, finish desired and many other variables. THE most common mistake is to run the feeds or spindle speed too fast!

COMPETENCY:
Feeds and Speeds



ACTION ITEM:

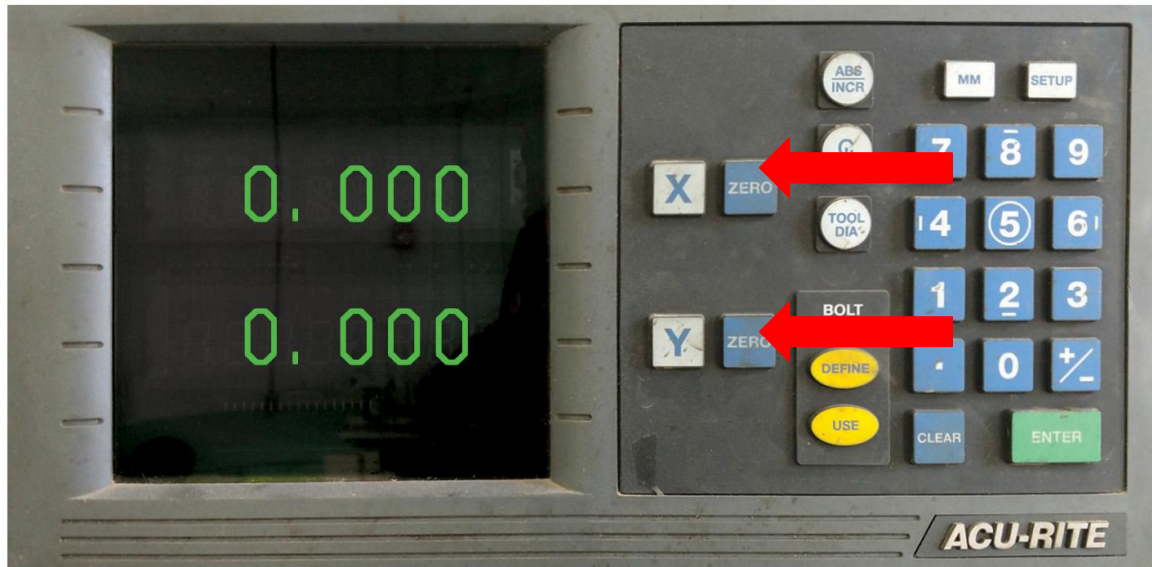
ASK STUDENT QUESTIONS

QUESTIONS:

- Do you understand the difference between “feeds” and “speeds”?
- Do you understand the relationship between “feeds”, “speeds” and depth of cut?
- Do you understand the implications of having the spindle speeds and feed rates set too low or too high?

Part 14:

Using the Digital Read Out (DRO)



On the right side of the machine is a Digital Read Out screen or DRO. The screen measures and indicates movement in the X and Y axis. Each Axis can be set to zero or to a desired value. The DRO has its own power button that must be turned on.



As an alternative to the DRO you can use the dial indicators located on each of the Axis Handles. These can be used to track movements. The increments on the dials are .001".

COMPETENCY:

Using the Digital Read Out (DRO)



ACTION ITEM:

HAVE THE STUDENT MOVE THE X AND Y AXIS AND ZERO THEM.
NEXT HAVE THE STUDENT ENTER A VALUE OF .125" IN THE Y
AXIS AND MOVE TO THAT VALUE.

QUESTIONS:

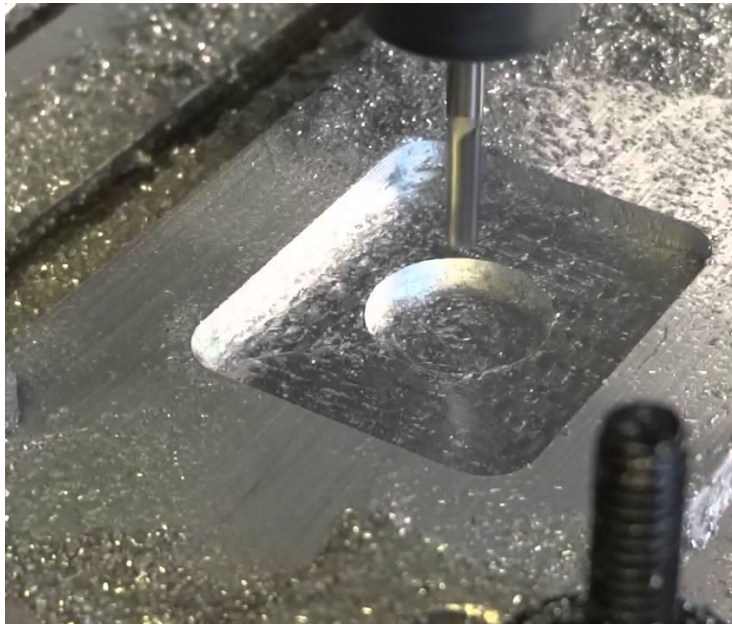
- Does the student understand how to “zero” the X and Y axis?
- Does the student understand how to enter a desired value?

Part 15:

Lubrication and Cutting Fluid



Cutting tools and work pieces will heat up during machining. Coolants reduce heat build-up by flowing over the surface of the cutting tool and work piece, picking up some of their heat, and carrying it away. There are many types of coolants, lubricants and cutting fluids. You can use WD-40 as a decent general lubricant that can be applied by spraying it on the tool and workpiece or using a brush. Never get near a rotating tool.



Lubricants also reduce friction and clear space for the formation of new chips. They do so by lubricating newly formed chips, allowing them to slide away more efficiently and by flushing out chips that tend to stick in confined spaces. Use of coolants and lubricants prolongs tool life, improves results, and allows faster cutting speeds.

COMPETENCY:

Lubrication and Cutting Fluid



ACTION ITEM:

ASK THE STUDENT QUESTIONS

QUESTIONS:

- Do you understand what cutting fluid to use and how to apply it?
- Do you understand the importance of chip removal and how to do it safely while the spindle is off?



REVIEW

ACTION ITEM:

ASK THE STUDENT QUESTIONS

QUESTIONS:

- Does the student have any questions about the tutorial?
- Is the student ready to watch you use the machine and begin the hands-on component of the tutorial?



ACTION ITEM:

1. HAVE THE STUDENT OBSERVE YOU:
2. LOAD A WORKPIECE AND BIT.
3. SELECT AN APPROPRIATE RPM SPEED
4. WITH THE SPINDLE ON-SET A Z ZERO AND RAISE THE KNEE .050" AND FACE OFF THE WORKPIECE
5. WITH THE SPINDLE ON-SET AN X OR Y ZERO AND SIDE MILL ONE SIDE USING PASSES WITH A CUT DEPTH OF .050".
6. TAKE OUT THE BIT AND COLLET, THE WORKPIECE AND SET THE RPM TO 1200 SO THE STUDENT HAS TO ADJUST IT.
7. HAVE THE STUDENT PERFORM THE EXACT SAME OPERATIONS YOU JUST DID TO MAKE THEIR OWN CHIPS

QUESTIONS:

- Did the student competently and safely make chips?
- Are you satisfied that the student can competently use the machine?



REVIEW

ACTION ITEM:

- IF THE STUDENT HAS COMPLETED THE CERTIFICATION TUTORIAL AND YOU ARE SATISFIED WITH THEIR PERFORMANCE: GO TO THE CERTIFICATION SPREADSHEET AND CONFIRM THAT THEY HAVE COMPLETED THE HANDS-ON PART OF THE CERTIFICATION AND INFORM THEM THEY CAN NOW USE THE MACHINE DURING OUR OPEN HOURS.