Advanced Technology and Manufacturing Institute

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Mill Operating Procedures

Birmingham Knee Mill

WARNING

The operation of machine tools carries the inherent risk of maiming, disfigurement, and death. Thoughtful attention to all posted warnings, safety instructions, the condition of equipment, and the precepts of this manual is ***required*** *for operation of machine tools at ATAMI. Failure to comply with safety standards will result in revocation of machine tool privileges.*

Contents

Introduction

The purpose of this document is to provide guidance on the safe and responsible operation and maintenance of the Birmingham Knee Mill at the Advanced Technology and Manufacturing Institute. This manual is meant to be used in conjunction with the ATAMI Client Training and Tool Use Guidance.

1. Safety Requirements

The most important safety feature of any machine tool is the operator. Prior to using the mill, ATAMI tenants and OSU researchers must complete the ATAMI introductory shop safety course and mill operator safety course, or OSU's ME 250 (Introduction to Manufacturing Processes) course. The following safety requirements must be observed when using any machine tools:

a. Full mental alertness is required for safe operation of machinery. Never operate under the influence of drugs, when tired, while distracted, or while ignorant.
b. The operator shall be correctly attired, including close-toed shoes, safety glasses, and a lab coat.
c. The machine tool shall be operated in accordance with this publication and the manufacturer's manual.
d. For ATAMI tenants and OSU researchers, the time and purpose of the use shall be logged in the ATAMI resource tracker.
e. Secure the machine upon any indication of damage or abnormal operation, and immediately inform an ATAMI staff member.

Failure to adhere to these requirements will result in loss of machine tool privileges until the operator safety course can be re-taken.

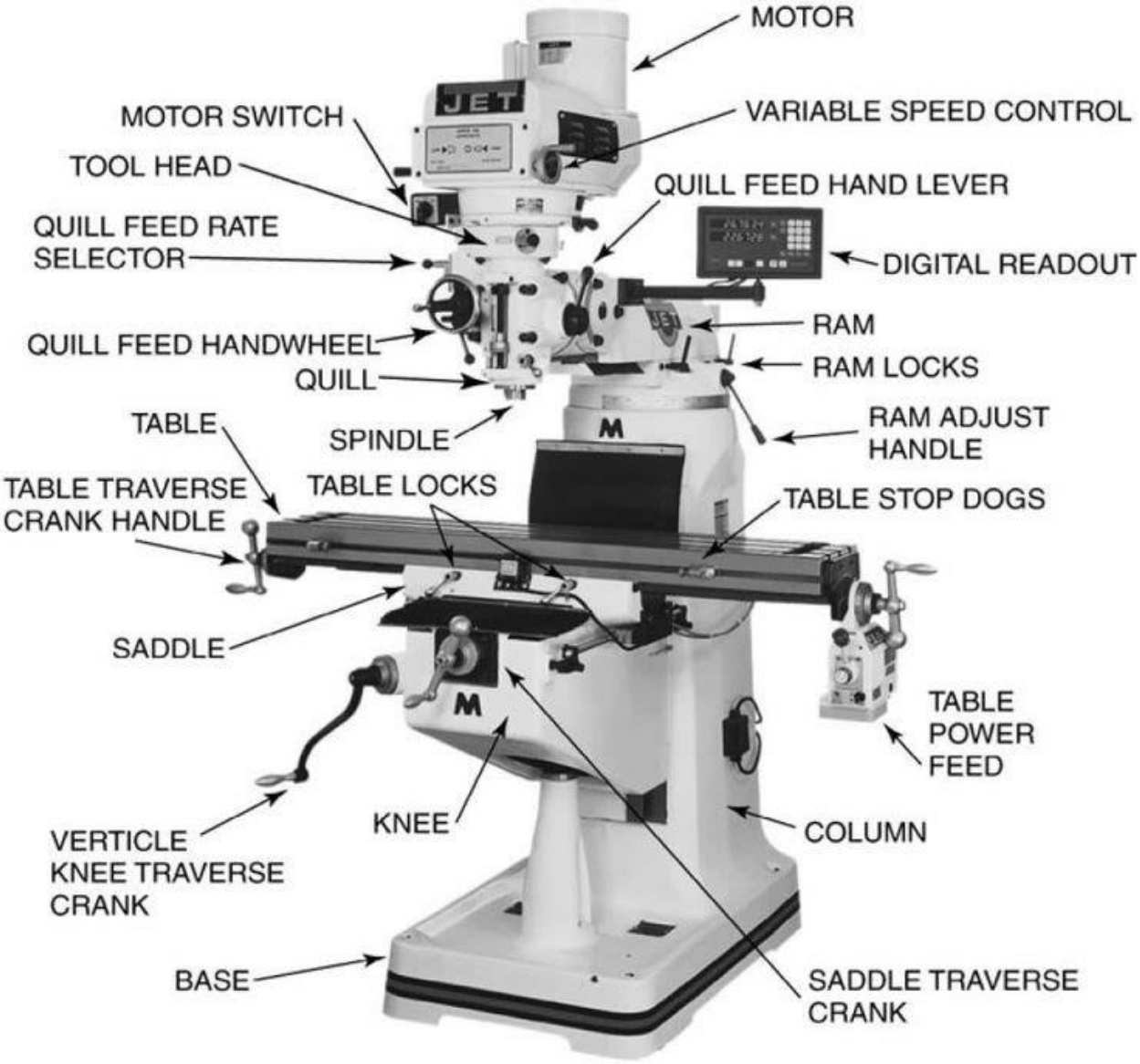
2. Precautions

The following specific precautions apply to operating the mill due to its design, construction, or condition:

- ROTATING PARTS. Always keep hands and body at a safe distance from rotating parts—especially those with projecting surfaces. Never hold anything against rotating workpiece that can pull you into lathe.
- ENTANGLEMENT. Entanglement with a rotating chuck can lead to death, amputation, broken bones, or other serious injury. Never attempt to slow or stop the lathe chuck by hand, and always roll up long sleeves, tie back long hair, and remove any jewelry or loose apparel BEFORE operating.
- AUTOMATIC MOTION. Special care should be taken when using the automatic feed capability of the machine, with particular attention paid to speed and direction of the table relative to the tooling.
- AWKWARD POSITIONS. Keep proper footing and balance always when operating machine. Do not overreach! Avoid awkward hand positions that make workpiece control difficult or increase the risk of accidental injury.
- SECURE WORKPIECE. An improperly secured workpiece can fly off spindle with deadly force. Make sure workpiece is properly secured before starting the lathe.

- REMOVE ADJUSTING TOOLS. Tools left on machinery can become dangerous projectiles upon startup. Never leave chuck keys, wrenches, or any other tools on machine.
- USE THE CORRECT TOOL FOR THE JOB. Only use this tool for its intended purpose—do not force it or an attachment to do a job for which it was not designed. Never make unapproved modifications—modifying tool or using it differently than intended may result in malfunction or mechanical failure that can lead to personal injury or death!
- MACHINE INSPECTION. Inspect the machine tool prior to starting. Do not use the machine if any abnormal condition exists. Ensure all adjusting and measuring tools are removed or do not interfere.

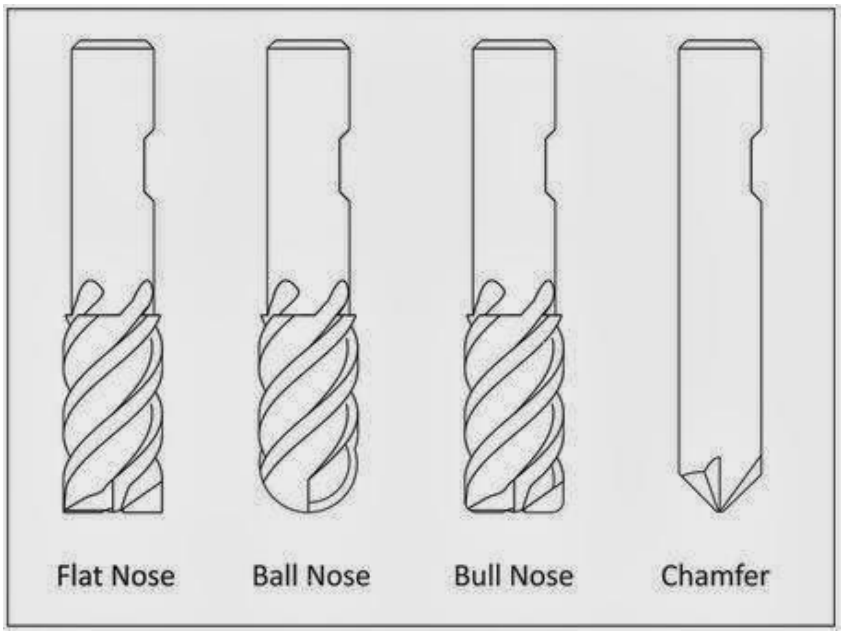
3. Machine and Tooling Description



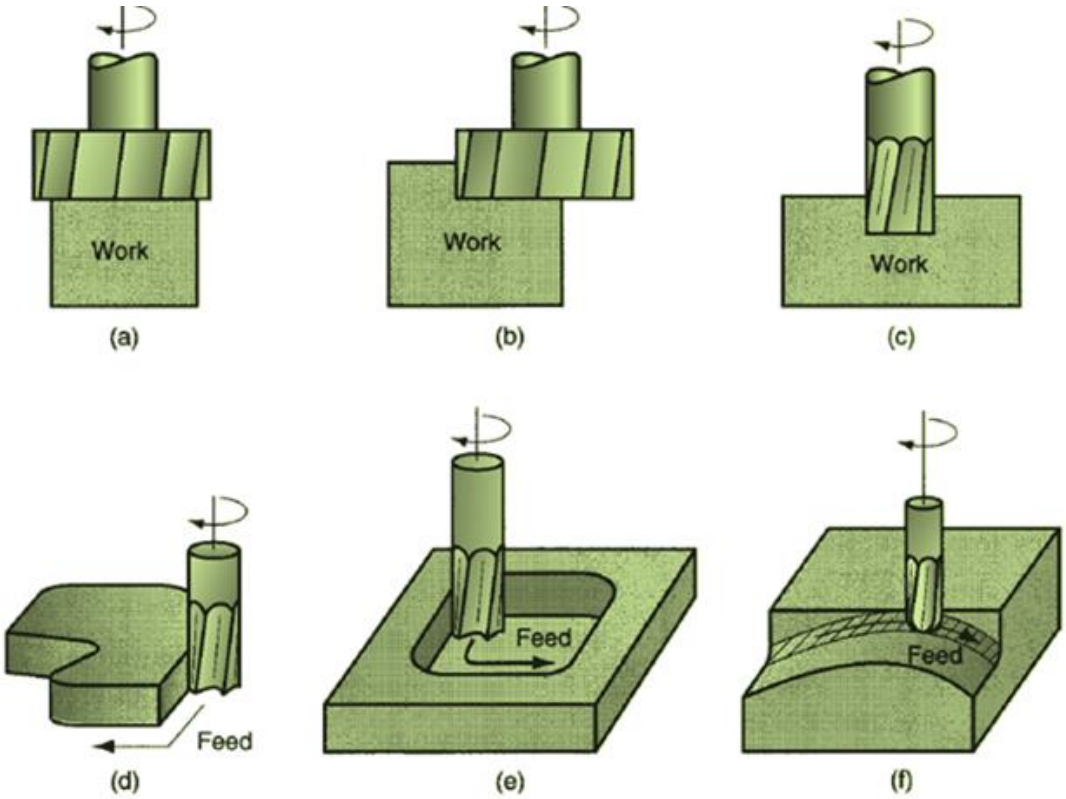
A knee mill by JET similar to the Birmingham model in use at the ATAMI machine shop

Mills are machine tools removing material with a rotating cutter while advancing the workpiece past the cutter. The knee mill is used to perform a variety of operations at precise tolerances. The profile of and direction of the cut are determined by a combination of work holding arrangement, machine configuration, and cutter type.

The Birmingham knee mill in use at ATAMI is capable of a wide variety of machine operations and configurations. Standard tooling such as end mills, ball mills, face mills (for very fine surface finishes), rough cutters (for removing large amounts of material), boring bars (for achieving large, precise inside bore holes), and reamers (for boring precise diameters are all available for use.



Some standard end mill designs (above), Common milling procedures (below).



Milling is useful for dimensioning parts to precise tolerances, creating pockets or slots in a material, and achieving features like dovetails, chamfers, and bevels.;

Types of milling cutters

Setup

1. Workholding

Workholding for mill is normally accomplished with a machinist's vise. Please contact ATAMI technical assistants if your work piece cannot be milled with the machinist's vise.

A traditional mill vise like the one typically installed on the knee mill.

Securely fastening the work piece to the vise or work bed is vital for safe operation of the mill. Improperly secured work pieces can pose a significant missile hazard. If your part does not fit in the machinist vise, or is geometrically incompatible, contact the ATAMI technical assistants for other work holding options.

2. Speed Selection

The mill cutting speed and feed rate can be adjusted for various materials, depths of cut, and surface finishes. Cutting speed is defined as the rate at which the material being cut passed the cutting edge and is always expressed in inches per minute or feet per minute. Cutting speed is determined from a table based on depth of cut and the material of the workpiece. The cutting speed of the mill is adjusted by changing the RPM of the spindle and the travel speed of the table. Spindle speed can be adjusted by changing the drive belt positions and with the HI-LO power switch on the left side of the mill head.

3. Tool Selection and Holding

Tool selection is based on the material of the workpiece and profile of cut desired. Select a cutter profile appropriate to the desired operation. For most common operations, there will be a cutter already mounted in a quick-change tool holder. The Birmingham knee mill uses an R-8 taper for tool holding. A set of taper collets is available with the mill. Some tools, such as the boring bar, face mills, and fly cutter, do not mount to collets but have their own tool holder installed.

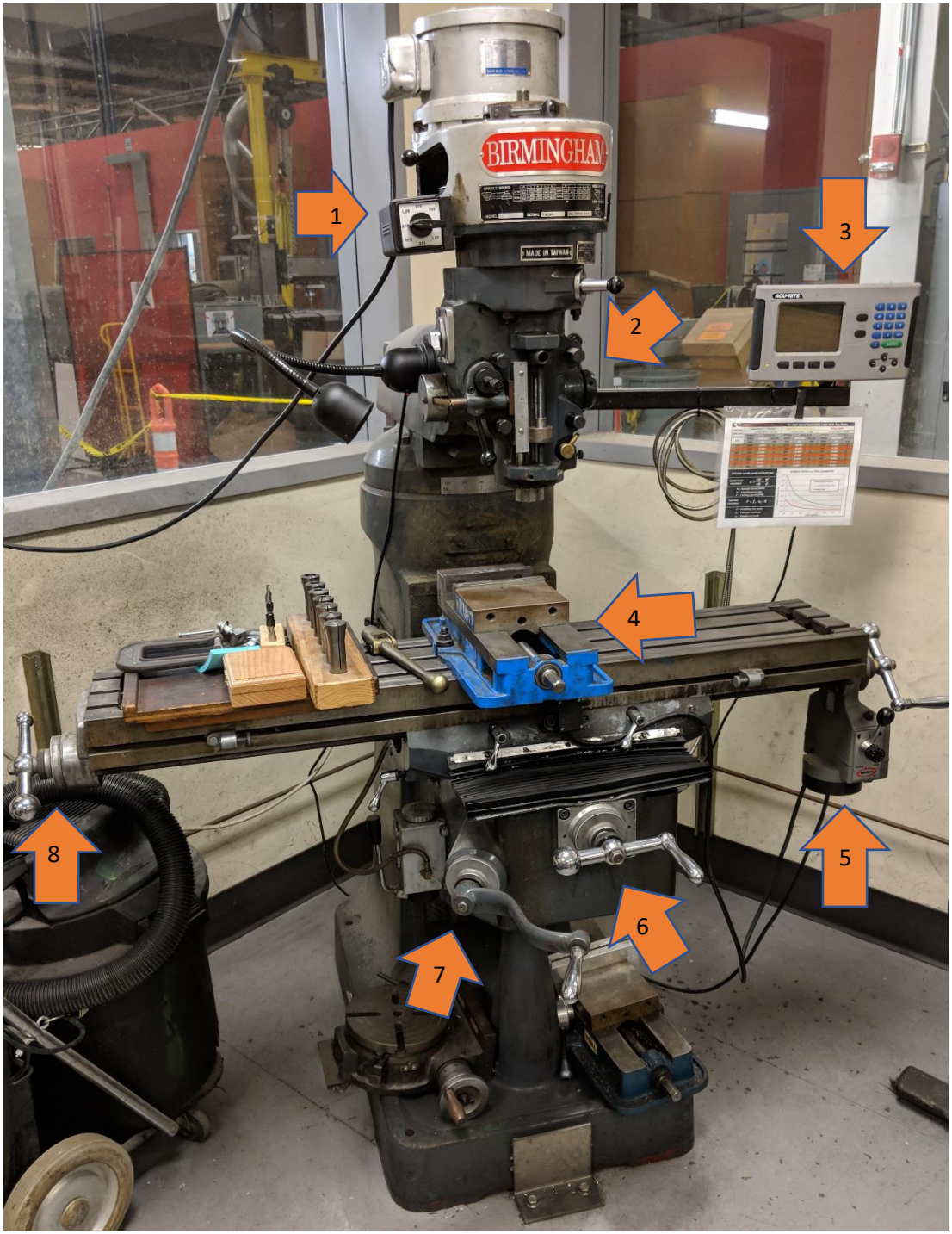
A knee mil machine is valuable in part due to the ability to quickly change cutters to fit different requirements. This mill uses R-8 collets to hold tools of various shank diameters. To change the tooling on the milling machine:

1. Ensure the machine is powered off
2. Using a ¾” wrench, loosen the draw bar nut at the top of the head until it spins freely.
3. Using the plastic orange mallet stowed with the mill, gently tap the top of the drawbar while holding the tool and collet currently in the spindle. The collet should release promptly, leaving you able to remove the tool and collet from the spindle.
4. Install the desired tool and collet in the spindle.
5. Tighten the drawbar by hand until the tool and collet are retained.
6. Use the spindle brake and ¾” wrench to tighten the drawbar.

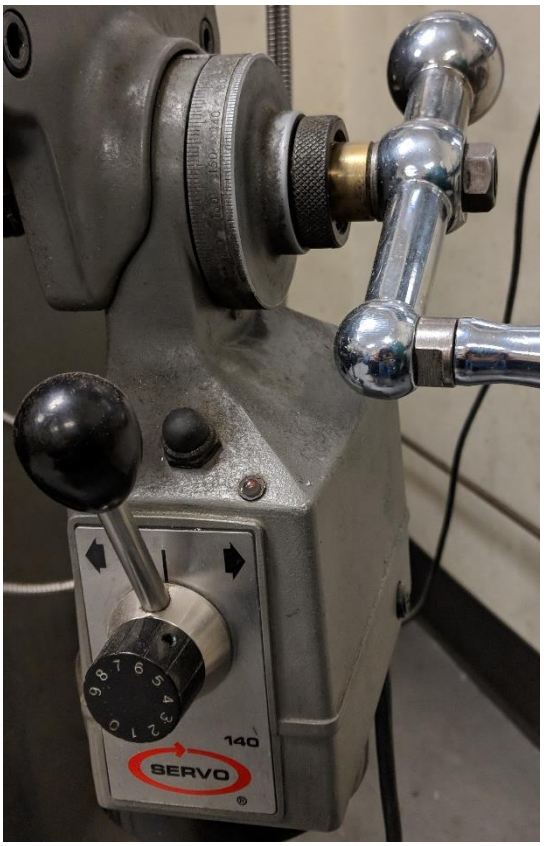
If you do not know if tooling for your desired operation exists, or if you are not sure how to mount the tool you wish to use, please contact the ATAMI technical assistants.

4. Controls

The Birmingham knee mill has controls for spindle speed, manual table X and Y travel, manual spindle Z travel, powered Z and X travel, and the digital read-out (DRO) display.

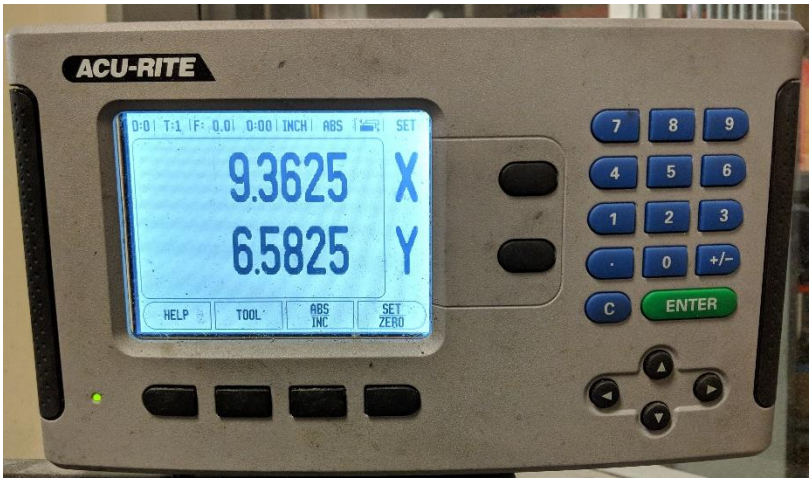


The main control inputs of the Birmingham Knee Mill: 1) speed control and Fwd/Reverse power switch. 2) Manual spindle feed 3) Digital Readout (DRO) 4) Machinist's Vise 5) Powered table X-axis control 6) Manual y-axis table control 7) Table height control 8) Manual table X-axis control (handwheels on both ends of table)



(Left) The powered table controls for the knee mill. The speed is selected from the dial, with larger numbers corresponding to faster travel. The lever is moved to select the direction and begin/halt table movement. The center position is stop. The black rubber button is for rapid travel and should not be pressed during normal operation.

(Right) The DRO receives inputs from the X and Y axis and can be used to quickly and easily locate tools and parts on the table. The manual for the DRO is available on the ATAMI shop tools web page.



Standard Operations

1. Squaring or Dimensioning Stock

A common use for the knee mill is to generate stock of precise dimensions for use with the CNC mill. To generate a precisely dimensioned stock from a piece of rough cut stock:

a. Rough cut the stock, leaving sufficient material to generate correct dimensions.
b. Select a reference face to work from, and mark it (R). If your stock already has one face known to be square and true, use this face. If not, face one side of the piece, and use this as the reference.
c. Ensure the vise, workpiece, and parallels are free of chips and burrs.
d. Place the workpiece in the vise such that the marked face is up against the fixed jaw. Place a small piece of plastic or softwood between the workpiece and the moving jaw. This buffer piece will deform when the vise is shut, holding the workpiece squarely against the fixed jaw.
e. Mill the upper face and mark it (1).
f. Rotate the workpiece such that the newly marked face (1) is against the fixed jaw of the vise and the reference face is pointing down.
g. Mill the upper face and mark it (2).
h. Continue rotating the piece in this fashion, marking faces (3) and (4). Face 4 will be the former reference face. If you sized your stock correctly, facing side 4 down to final dimensions will remove the reference mark.
i. Rotate the stock 90 degrees so that face (5) or (6) is upward. Use a fixed machinist's square, referenced from the floor of the vise, to ensure the stock is perpendicular.
j. Mill the upper face and mark in (5)
k. Rotate the piece so the last remaining un-milled face is pointing up, using the vise floor or parallels as reference surfaces.
l. Mill the upper face and mark it (6).

This should generate stock with six flat, perpendicular faces.

2. Boring

Boring is creating a precise hole in a part. Where single-pass drilling, such as with a drill press, can have variations up to +/-.015", boring is intended to produce a feature with much tighter tolerances. This is accomplished using multiple tools and passes. Because of the variety of circumstances may arise in the creation of this feature, the procedure is intentionally less detailed than the procedure for squaring stock. If you have questions about how to apply this process to you particular part, please get in touch with the ATAMI Technical Assistants.

a. Punch or center drill the hole location on the stock
b. Using a plunge-cutting end mill or twist drill, rough cut the material, leaving sufficient thickness for finishing with a boring bar or reamer.

c. Depending on the size of the hole and finish desired, remove remaining material with the boring bar or reamer. Final passes should be shallow and made at high speed with a slow feed for best finish.

Maintenance

1. Care and Feeding

After using the knee mill, clean all accessible surfaces with a brush and disposable cloth wipes. Wipe down all working surfaces, ways and rails with a light coating of oil. Remove any tools and workpieces from the mill. If any moving part shows signs of resistances, binding, or chattering, use the oil pump located below the work table on the left side of the mill to send oil through the system.