How to Make Workholding More Productive

KURT

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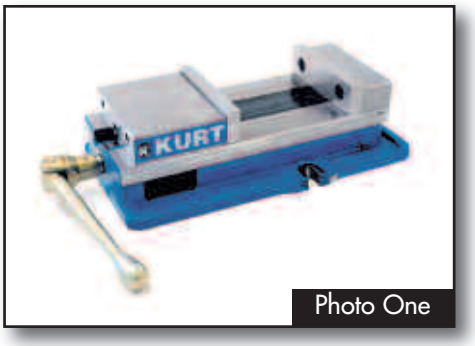

Photo One

Principle Of The Workholder

There are many types of machine workholders including clamps, chucks and vises. Of these, the most widely used are various styles of vises, all of which are designed to locate and hold a workpiece securely while it is machined to specified dimensions and tolerances.

Most machine shops in the world today use vises as their primary workholding tool. There are good reasons for this. The most important are versatility and economy. A significant amount of planning may be applied to the machining process, however it must begin with the workholding method. Generally, the most cost effective and adaptable workholder is a vise. The size and configuration of the vise is dictated by the workpiece shape and the machine it is used on. The cycle time length, if very short, may make using a power operated vise desirable to reduce the time of the clamping cycle. The material to be machined and other production factors also impact the final choice of vise types.

The objective of virtually all machining setups requiring workholding and the use of vises is maximum productivity. This means making chips with only minimal interruptions, providing an opportunity for the operator to tend additional machines during the unattended machining cycle. This is true for simple knee-type milling machines and complex, high speed machining centers alike. Equally important, the workholding needs to cover most of the available machining area of the machine to maximize the machine's number of parts per set-up and thus productivity.

Today's vises range in configuration from relatively simple single station models to very elaborate multiple station designs. The majority of these vises are made of ductile iron for maximum strength, rigidity and vibration damping characteristics. Most vises consist of a mounting base or body which is secured to the machine table, a stationary jaw against which part material to be machined is located, a movable jaw and screw mechanism. When tightened, the movable jaw is pushed or drawn forward by the screw mechanism thus clamping the workpiece against the stationary jaw. This clamping action holds the part securely while the machining operation takes place. (Photo One)

Vises are simple, relatively fast and easy to operate. They are basic to machining operations and have been for hundreds of years. Many refinements of the basic vise concept have been made, particularly in the last 50 years to improve precise repeatability, increase part density within the workholder and to automate its operation with pneumatics and hydraulics.

History Of Vises

Vises date back to the beginning of the Industrial Revolution. Their refinement parallels the advancements in machine tool technology, which was greatly accelerated in the 1960's with the advent of computer numerical control (CNC) machines. These CNC machines are "smart" machines, increasing the speed, accuracy and versatility of the machining process. They greatly ease the reliance on operator skill to produce accurate parts. The function of the operator is changed from craftsman/artisan to programmer/setup person.

With the demand for higher precision parts and greater productivity starting in the 1960's, came the birth of the precision machine vise. Greater burdens were placed on workholding for higher quality and increased cost effectiveness and this was also true for basic machines such as knee-type mills and emerging machining centers.

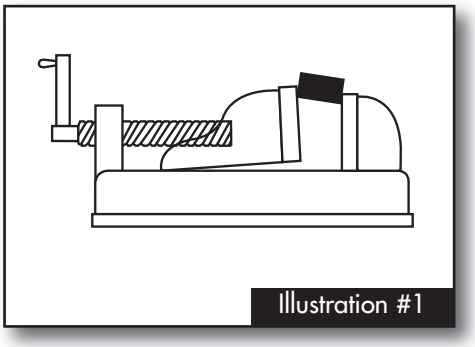

Illustration #1

Early screw-type vises deflected, causing part misalignment. Moveable jaw tilted upward also tilting part.

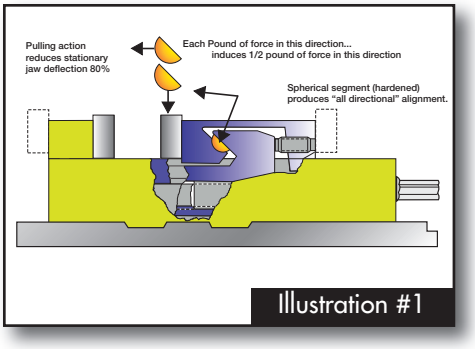

Illustration #1

Early screw-type vises deflected, causing part misalignment. Moveable jaw tilted upward also tilting part.

The precision machine vise provided the workholding solution.

Early vise designs, when under pressure, deflected so that part alignment was a constant problem. Workpieces lifted and had to be forced down with a lead hammer or other dead blow device so that repeatable part-to-part machining was possible. The precision machine vise, originally designed as a single station device, was unique in that it incorporated a ball segment in the movable jaw and had an angular nut face. In the industry, this vise was known as the "Anglock®", which when clamped, exerted a downward force on the workpiece. Thus, firm contact with the vise bed or locators was maintained without hammering. This type of vise aligned and held parts more accurately and securely than any previous screw type vise. (Illustration One and Two)

What was so significant about the Anglock's development was that it allowed knee-type mills and the latest CNC machines to do their best work by locating and clamping parts in their most immobile state possible. The stiffness created through the design that pulled the jaw down had the added benefit of pulling the nut and driving the movable jaw up creating a sandwich of vise body, nut and movable jaw. The resulting stiffness and dampening allowed a significantly lighter vise to be offered, allowing for manual lifting and positioning of the vise on a machine table, which contributed to its popularity.

Double station, multiple station, self-centering, hydraulic, vertical and many other versions were developed out of the basic concept of the original single-station, precision machine vise. Today, there are hundreds of vise models in many sizes with many options including automation, which gives the manufacturer an infinite arsenal of choices.

Design And Operation Considerations

To address the workholding needs of a particular machining operation, one needs to consider part size, material, machine speed, feed rate, and the quantity of parts to be produced.

Single part production or low quantity requirements generally make a single vise setup a good choice. The part configuration will point toward either contoured jaws or any number of standard or special jaws. The gripping area for the planned operation must allow for sufficient depth of jaw engagement (bite) to safely allow the planned operation to take place.

Higher quantity lot sizes make multiple vise setups desirable. The workpiece size determines the spacing between the vises as well as the vise size itself. Generally attempts must be made to produce the maximum amount of parts per cycle. Many additional operations by the same operator can then be done simultaneously. The key to freeing the operator is quick clamping and the highest efficiency of the workpiece loading cycle. This includes prepping the work area for thorough chip flushing and cleaning. There are times when the NC machine can be programmed to flush the chips with programmed moves. Other ways to keep the machine in the cutting mode on smaller parts include palletizing the workpieces and then exchanging pallets in the vise as a pallet receiver. The actual workholding in these applications is best done with miniature wedge clamps that have similar features as the original "Anglock. These wedge clamps will not loosen under vibration and can clamp two parts with the turning of one screw.

Deciding to use a multiple vise setup requires considering the cost of the setup itself. When using a multiple vise setup, it is common practice on large quantity lot sizes that repeat periodically to mount the entire setup on a base plate or

tombstone so it can be stored intact between uses along with all the cutting tool holders. When this is not feasible, grid plates with dowel hole patterns are kept on the machine. Vises are then easily located and fixed to the plates. This allows the setup to be guided by the spacing and the dowel patterns.

Planning The Workholding – Products and Accessories

Process planning requires dividing the machining process into steps best suited to the available machines. Generally, it is best to do as many operations in one clamping as possible. This is accomplished most often when using the vises on an indexing table or on a horizontal machining center. Smaller machine shops are more likely to plan their workholding around knee mills or vertical machining centers. When using an index table on these types of machines, it is possible to machine on 3 sides of the workpiece. This will require workstops and jaws to be located away from the cutting areas. Often, the use of special designed jaws will allow machining areas of the part that are otherwise not accessible. Also, parts carved from solid materials can be manufactured into strips of repeated parts, which allows making several parts per vise.

Selection – Workholding For Simple Machines Such As Knee-Type Mills

Knee Mills are a favorite of most toolmakers and "model shop" machinists. In this environment, lot sizes are small and setups are constantly required. Under these circumstances, a versatile workholding system employing vises will save considerable time. As the number one workholding choice, the full range of vise accessories can help with setup reduction. Among these are carvable jawplates, quick positioning workstops, and chipshields. There are also accessories for locating the part edge and indicator spindle attachments with which to mount indicators for alignment of the part and to find the center of a tooling hole. Typically, work done per setup is short in actual time spent in the cut while long in the time spent planning. To eliminate some of this downtime, quick change jaws have been developed, which, in some cases can reduce changing jaw plates to just 5 percent of the previously required time.

Selection –Workholding For Complex Machines Such As Horizontal And Vertical Machining Centers

As the acquisition cost of a machine rises, so does the burden rate and the need to keep the machine from sitting idle. Part loading time and setup are an integral element of downtime and need significant attention to maintain high efficiency. Workholding again becomes a central element in maximizing machine "up time".

Considerations in selecting the best available vise clamping and setup solution.

Following are considerations for maximizing productivity utilizing vises on frequently encountered machining situations:

1) Vise selections and their characteristics (number of stations, parts per station, means of actuation, etc.).
2) Jaw plate considerations and its effect on part contact and repeatability.
3) Locating systems for setup reduction and position accuracy.
4) Workstop systems.
5) Helpful accessories to make the clamping job easier.

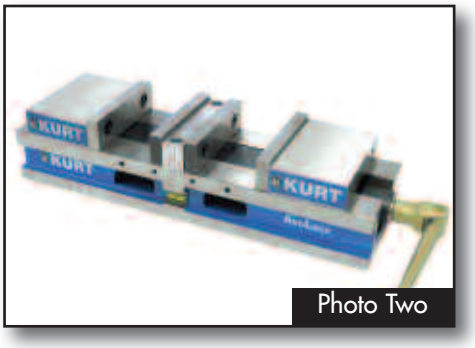

Photo Two

Double station vises provide multiple part workholding for better spindle utilization, reduced tool change time and reduced machine travel from part to part.

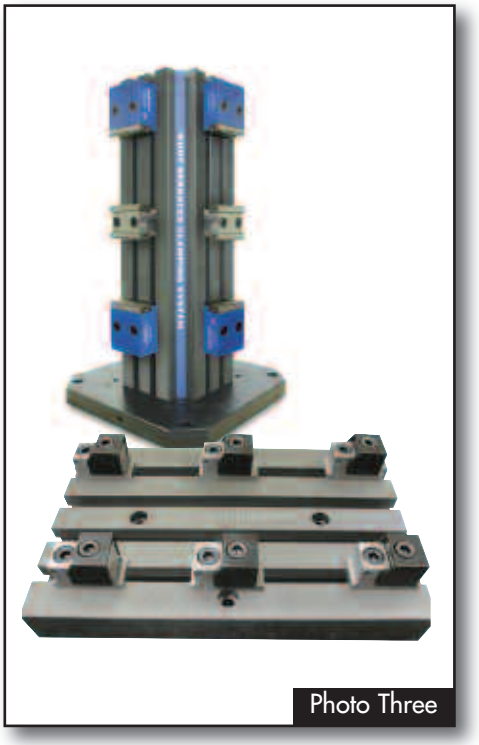
Photo Three

Serrated workholding systems are available in eight and twelve clamping station tower and two different multiple station pallet systems. They provide repeatable clamping and provide flexibility to quickly change setups for varying part requirements.

Vise selection and their characteristics

A) The key factor in choosing a vise for a knee mill is the vise opening and whether or not a swivel base is needed. Also for consideration is the addition of a workstop on the machine table or affixed to the rear of the stationary vise jaw. If parallels are included, the no-lift movable jaw will keep these parallels in contact with the part for correct alignment in the mill.

B) Workholding selection for vertical and horizontal machining centers should be based on desired density, vise opening, clamp pressure needed and shape of the part. The stationary jaw of a pull type vise is cast integral with the vise body. It is a good selection when density and absolute minimum deflection is needed. Side mounting or end mounting is possible. Also, pull type vises can be aligned next to one another without spaces. The primary benefit of a pull type vise is that only a minimum amount of the clamp force actually exerts bending forces on the vise body so that a significant force actually backs up the stationary jaw. Pull type vises are made of ductile iron, work well on thin machine tables, and are relatively light in comparison to other types. They have hydraulic and air operating options. Also, the stationary jaw can be positioned toward the operator or facing the machine column. This allows positioning the vise screw where needed.

C) High density requires double station vises. These vises have two clamping stations, pushing the workpieces toward the stationary vise jaw block between them. This neutralizes the bending pressure against the center of the vise, allowing a relatively thin section for the stationary jaw, thereby saving valuable space. Double station vises feature a ductile iron body that dampens machine vibration, and is superior to other lighter materials. This is most notable when heavy metal removal rates are required. (Photo Two)

D) Highest workholding density requires double station vises equipped with special carvable jaws plates or carvable jaw blocks. When workpieces are small enough two parts can be clamped in each jaw set or four parts in each double station vise. This requires four workstops on each vise or the machining of part locating nests. Carving can be done using carvable jaw blocks made of ductile iron or aluminum for lighter operations. When selecting this type of vise, it is important to recognize significant differences in performance between vise brands. Most significant is the amount of movable jaw lift under a given clamping pressure. The easiest way to compare is to use a dial indicator next to the workpiece on top of the movable jaw taking readings at different pressures. The best and most accurate vise is the one with the least amount of jaw lift.

E) The next highest workholding density can be achieved with cluster vises where multiple vises are machined into a single body. This type of workholding is generally available in less standard varieties but can be economically made to order. The advantage of cluster vises is that they remain in exactly the same relationship to each other compared to trying to align multiple vises in a workholding setup.

F) Highest workholding density is achieved when the movable vise component is a module that can be moved in small increments on a serrated base. The modularity of these systems allow the user to configure the equivalent of custom fixturing with standard "off-the shelf" components. Serrated workholding systems allows manipulation of all variables normally encountered in a high density setup. Stationary jaw blocks can be moved wherever needed and can be made of a large variety of materials to fit clamping requirements. This serrated system is especially suited for tombstone applications where three sides of a part need machining and the clamping components are relatively small. Vertical machining centers with pallet changers are also an excellent application for a serrated clamping system. (Photo Three)


Photo Four

Zero-point workholding systems are available in heavy duty, automatic, standard and custom versions for workholding in seconds on vertical and horizontal machining centers.

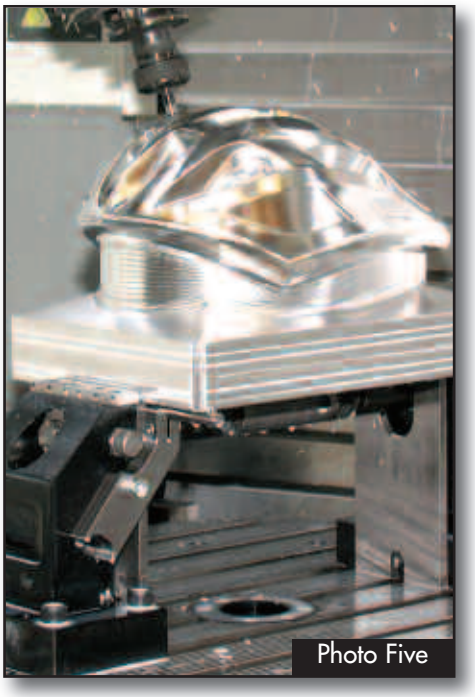
Photo Five

Complex shapes, undercuts and difficult angles in a single setup reduce tooling costs and labor time resulting in a better cost per part using this Kurt 5 axis clamping system.

G) Self-centering vises are very similar to double station vises except that they are designed to precisely locate components to their respective centers and are accurate within .0002 inch repeatability. This style vise when used in a pair has an adjustment feature which allows precise matching of the centers.

H) Zero-point workholding systems are designed to integrate with new or existing workholding devices such as Kurt vises and fixtures. They provide multiple workholding stations with ultra accurate setup on either horizontal or vertical machining centers thereby completely eliminating operator setup errors. With repeatable positioning accuracy of ±.0.0002 on typical part runs, they ensure high quality part finishes, no scrap parts and substantial setup time savings. For example, a typical workholding setup change usually requiring 20 minutes is done in less than 2 minutes using a zero-point VB DockLock system. (Photo Four)

I) Five axis clamping systems are designed to take advantage of the five axis machining capabilities of the latest machining centers. They provide up to 40 kN clamping force for obstruction-free machining on five sides of a part. This allows for high speed, continuous 5-axis cutting motion of sculptured surfaces, pockets and other 3-dimensional features in a single clamping setup. (Photo Five)

Jaw plate considerations affecting part contact and setup repeatability

A) The simplest and most commonly used jaw plates are case hardened. They are mounted with socket head cap screws. They fasten the plate to the jaw block with bolts on the inside of the clamping face. This style of jaw plate is best suited when higher than standard jaw plates are required. These plates are available in many variations including magnetic inserts which hold parallels from moving.

B) Vises equipped with indexable carvable jaw blocks or which index opposite jaw plate mounting faces can present a new jaw face in less than 10 seconds per jaw. All that is needed to make the change is to lift the jaw block off the vise bed, rotate to 180^{O}, reposition it and snap it down. The stationary block has 2 top mounted screws for repositioning which takes care of two jaw faces when the change is made. (Photo Six)

C) Serrated jaw plates in all of the above configurations are useful for holding raw stock material where marking of the workpiece is allowed. Generally these are for extremely heavy material cuts.

D) Shaped jaws, typically V-shaped with different V-depths machined horizontally and vertically on the jaw faces, will allow holding one or two round parts of identical size either perpendicular to the vise bed or parallel to the vise base. Again, mounting can be standard front-face and counter bored for the bolt heads. Step jaws also belong in this category. They are popular because they replace parallels and they do not have the residue buildup problems that parallels present. Neither are parallels practical on tombstone or production CNC applications.

Locating systems for setup reduction and accurate positioning of vises

Vises with precision ground outside edges are easy to position alongside dowel pins on grid plates. Double station vises have ground edges with a dowel hole pattern on the bottom surface utilizing both metric and inch dowel patterns. This allows most existing grid plates to serve as a locating base for very fast and accurate setups. Additional hole patterns are located under the movable jaw block and stationary jaw for additional mounting options allowing side-by-side mounting without gaps. On tombstone workholding configurations the base plate is typically the same

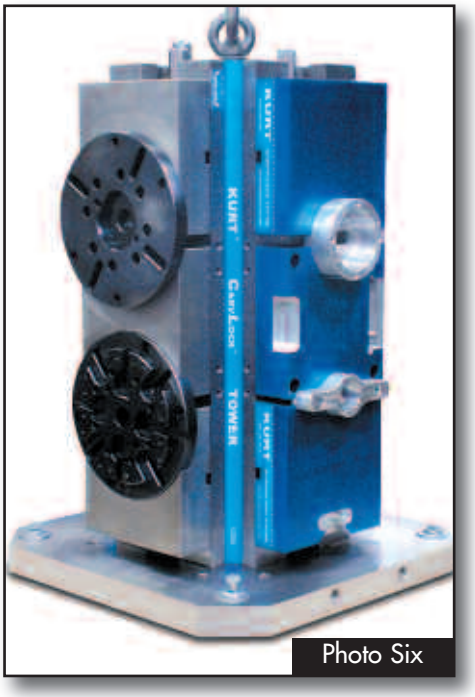

Photo Six

Carvable jaws are employed in this four-sided cluster tower workholding setup. Jaws on right are machinable. aluminum, on left are machinable ductile iron.

Photo Seven

size as the pallet and locates to the machine's pallet edge locator plates.

Workstop systems

A) Workstops are receiving more attention than in the past. The reason is that in multiple vise setups, jawplates can be interchanged quickly without loosing the location of the attached workstop. On occasion, the need to locate more than one workpiece in one jaw location requires that the workstop be extremely small, thus consuming little or no space between the parts so as not to interfere with adjacent vises. A vise jaw with a groove in its top face is available as a receiver for a work stop that cost-effectively fulfills these requirements.

B) Work stops attached to a threaded hole in the outside edge of a jaw plate work well for many applications. They are not suitable for multiple parts in one jaw set and do not allow vises to be located without a space between them. The same is true for similar workstops mounted along the vise body edges.

C) Workstops mounted directly to the machine table have the advantage of being located away from the vise allowing the locating of very long workpieces.

D) Workstops mounted to the rear of the vise reaching over the top into the locating zone also work well. A disadvantage is obstruction of the space above a jaw plate. This eliminates the freedom to use large cutters close to the jaw plate tops. These workstops also require repositioning during jaw plate changes and are not suitable for double station vises. Usually setup requires different size wrenches. They are difficult to set for precise spacing in multiple vise setups and require considerable setup time.

Helpful accessories make the clamping job easier

Many workholding gadgets have been developed by toolmakers to eliminate a particular workholding problem. Over the years, workholding manufacturers have developed products that make the operator's job more pleasant . A list of the most useful accessories include (Photo seven):

1) Speed handles with multiple knobs for fast vise opening and closing.
2) Vise handles with adjustable arm lengths.
3) Vise handles with torque readings for sensitive and repeatable clamping.
4) Vise screw extensions for freedom to reach through machine guards.
5) Hydraulic intensifiers for hydraulic vise models which eliminate the need for electric pumps.
6) Air cylinders with multiple pistons which achieve effective clamping pressures using standard 100 psi shop air.
7) Step key sets to adapt vise keyways to those of the machine.
8) A complete array of different workstops.
9) Countless specialty jaw plates and parallel sets.
10) Coolant and chip shields which mount in close proximity to the cutting action.

Custom Fixturing – When And How Used

Continuous production of high volume components may best be machined in a custom fixture. This will allow the highest density of parts in the machine and the locating of parts from points usually not accessible with a vise. Typically, these fixtures on vertical and horizontal machining centers are power clamped with elaborate spring-loaded pre-locators which keep parts in place until all can be clamped simultaneously. The fixture must be designed for thorough chip washing ease in order to present a clean fixture for reloading at the end of a machining cycle. Most clamps used for these

applications are swing away, rotating type hydraulic clamps which are offered as standard products by many companies. The best designed fixtures typically do not have exposed plumbing so that cleaning is easy. These types of fixtures are usually expensive initially but ultimately provide the best solution. When in-house tool building is planned, the resulting tooling is dependent on the experience of the designer. In certain cases, the workpiece designer may through simultaneous engineering, solve many future workholding problems during the early iterations to the part design.

Future For Workholding

As long as machines are needed to machine parts, vises and other types of workholders will be needed to position and hold materials while the machining operation takes place. Vise improvements and refinements will take place in the area of versatility, accuracy and speed of operation.

Automation of the workholding process offers the best payback when used in higher volume or continuous part production. At the early component design stage, consideration should be given to workholding using repeated robotic part clamping for part movement through several work sequences. For this reason, part designers need to consider their future workholding requirements while in the initial concept stages. Round parts may be positioned or clamped with collets or standard lathe chucks. Complex shapes with a significant flat surface can be vacuum clamped. Ferrous material can be held magnetically under some circumstances. Workholding ideas which may appear utopian today may have real practical application in the near future. For example, electro magnetic currents may solidify slurries of particles in which components of a fragile nature may be held in place. Epoxies which melt at very low temperatures are already employed for these types of parts. The development of extremely high RPM machining systems in many cases already has allowed economical production of parts from solid bar or plate by-passing many workholding problems. The same parts previously required castings in multiple machining requiring vises for clamping .

Machinists, process planners and engineers, through continuous improvement programs, are continually upgrading workholding applications. Many of their ideas have either reached or are on their way to the marketplace.

Fax back Form For Requesting Information, Pricing or Custom Workholding RFQ

First Name:

Last Name:

Company Name:

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Zip/Postal Code:

Phone:

Your Kurt Distributor Info

Distributor:

Contact:

Address:

Phone:

Fax:

Machine Information

Machine make and model:

"X":

"Y":

"Z":

Work Envelope:

(Ht./Length):

(Dia./Width):

Table Size:

Max. Table Load:

Quote Information

Quote Completion:

Completion of Workholding :

Type of Workholding:

Manual:
Hydraulic:
Parts to be Machined:
(include what material, cast or bar stock, what features are finished as the part comes to this operation, what features are to be machined in this operation)

Process:
(describe current and/or proposed process, quantity of parts on fixture)

Workholding Needed in this quote:
(also describe current workholding and any difficulties)