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Precision Universal Angle Vice

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Abstract - *The Precision Universal Vice, a specialized workholding tool engineered for high-accuracy machining tasks such as grinding, milling, and jig boring. Its primary feature is a 3-way tilting and swiveling mechanism, allowing the workpiece to be positioned at any compound angle through a 360° horizontal rotation, a 0-90° vertical tilt, and a lateral tilt of ±45° on either side. Each axis is equipped with graduated scales for precise setting and positive locking to ensure stability during operation.*

Built for durability and precision, the vice is constructed from high-tensile seasoned cast iron with fully hardened tool steel jaws (55 ± 3 HRC). The design emphasizes extreme accuracy, maintaining parallelism and flatness within 0.0012" (30 microns). This level of precision, combined with its ability to handle complex angular setups in a single clamping, makes it an essential tool for creating intricate parts that require multiple machining planes.

•Precision Universal Angle Vice (also called a 3-Way Tilting Vice)
•Workholding Tool
•Compound Angle Positioning

1. INTRODUCTION

A vise (American) or vice (British) is a mechanical apparatus used to secure an object to allow work to be performed on it. Vises have two parallel jaws, one fixed and the other movable, threaded in and out by a screw and lever.

Device consisting of two parallel jaws for holding a workpiece. One of the jaws is fixed, and the other can be moved by a screw, lever, or cam. Vises used for holding a workpiece during hand operations (such as filing, hammering, or sawing) are usually permanently bolted to a bench. In vises designed to hold metallic workpieces, the faces of the jaws are hardened steel plates, often removable, with teeth that grip the workpiece. Woodworking vises have smooth jaws, often of wood, and rely on friction alone rather than on teeth.
Work holding and releasing is the most essential act to carry out machining. These are commonly used in the machine shop.

- To hold the job in proper position
- To release the job quickly.
- To hold the job rigidly.
- To prevent vibration of the job while the machining is carried out.

An engineer's vice, also known as a metalworking vice or filter's vice, is used to clamp metal instead of wood. It is bolted onto the top surface of a workbench, with the face of the fixed jaws just forward of its front edge. The vice may include other features such as a small anvil on the back of its body.
There are many types of work holding devices like machine vices swivel vices, universal vice, pipe vice, T-bolt's 'U' clamps, Goose neck clamp, angle plate, Jigs and fixtures, etc. These are all mechanical type work holding devices.

There are three major types of work holding devices which are:

1. Mechanical type
2. Hydraulic type
3. Pneumatic type

In mechanical type, the screw rod is actuating the movable jaw. One end is connected to the movable jaw and it passes through a fixed type nut. When we rotate one end of the screw rod it will rotate in the nut and in turn moves the movable job. Here the rotary motion is converted into reciprocating motion.

Vices are used as holding device on machines like lathes, milling machine, drilling machine etc. and also by tool makers for holding jobs. Designwise three types of vices are very common in use namely plain vice, swivel vice and tool makers vice which is commonly known as bench vice.

A. Plain Vices

Plain vices bolted directly on the Milling machine table, is the most common type of machine vice used for milling operations. The vice may be fastened to the table with the jaws set either parallel or at right angles to the table T-slots. Work piece is clamped between the fixed and movable jaws.

B. Swivel Vice

The swivel vice is used to mill an angular surface in relation to a straight surface without moving the work piece from the vice. In construction it may be considered as plain vice which is mounted on a particular base graduated in degrees. The base is clamped on the table with the help of T.bolts.

C. Universal Vice

The universal vice can be swivelled in a horizontal plane like swivel vice as it has one fix ed horizontal axis which allows the workpiece to be rotated at any angle along it and can also be tilted in any vertical position for angular cuts due to its fully graduated 360 degree swivel base. The third angular slide with a moving axis allows for any setting in the 3D plane. The vice not being rigid in construction is mainly used in tool room work and hence is called as tool makers universal vice.

2. LITRETURE REVIEW

A literature review of the Super Precision Universal Angle Vice reveals its evolution from a basic clamping tool into a critical instrument for modern precision engineering. Historically, the development of the parallel vice in the mid-18th century, credited to Josef Heuer, marked the transition from primitive wedge-and-hammer systems to threaded screw mechanisms that allowed for repeatable accuracy. By the 19th century, the introduction of cast iron bodies in England provided the necessary rigidity for heavy-duty work, though modern literature highlights that early models suffered from brittleness. Current engineering standards, as seen in foundational texts like Hazra Choudhary's Workshop Technology, emphasize the shift toward close-grained, high-tensile seasoned cast iron and hardened tool steel jaws (55 ± 3 HRC), which provide the stability and wear resistance required for high-stress operations like milling and grinding. In contemporary research, such as studies by M.S. Kadam et al., the universal vice is praised for its 3-axis flexibility, which eliminates the need for expensive custom fixtures by allowing 360° horizontal rotation and compound tilting in a single setup. Technical manuals and patents underscore that the primary value of this tool lies in its extreme tolerances—maintaining parallelism and flatness within 0.0012" (30 microns). This precision is documented as vital for mold and die making, where even microscopic misalignments can lead to part failure. Ultimately, the literature identifies the Super Precision Universal Vice as a key factor in reducing cycle times and increasing manufacturing efficiency, serving as a bridge between manual craftsmanship and high-accuracy industrial production.

3. WORKING PRINCIPLE

Clamping Mechanism: A vice is a mechanical apparatus used to secure an object to allow work to be performed on it. It features two parallel jaws, one fixed and the other movable, which are threaded in and out by a screw and lever system to grip the workpiece securely.

Universal Positioning: This specific type is a universal vice, which allows the workpiece to be set at various angles. It typically has multiple axes of rotation: a fixed horizontal axis that allows the workpiece to be rotated at any angle, a fully graduated 360° swivel base for complete rotation along the vertical axis, and a third angular slide for setting in a 3D plane.

4. METHODOLOGY

1. Geometric Tolerances (Static Metrology)
Metrological verification is performed using a surface plate, dial test indicators, and precision mandrels to confirm the following:
• Parallelism of Jaws: The fixed jaw must be parallel to the base and the opposite jaw. Typical tolerance is 0.01mm/100mm.
• Flatness of Base: The accurately ground bearing surface must maintain flatness within 0.03mm (30 microns) to prevent "rocking" on the machine table.
•Squareness: The jaw faces must be perfectly perpendicular (90°) to the slide and the base within 0.01mm.
•Surface Roughness: The ground surfaces are typically measured for an
value (Roughness Average) to ensure smooth swiveling and sliding.

2. Angular Metrology (Axis Verification)
Since this is a "Universal" vice, each axis of rotation requires specific calibration:
• Horizontal Swivel (360°): Verified by rotating the base and checking the run-out of the fixed jaw relative to the machine spindle using a dial indicator.
• Vertical Tilt (0-90°): The graduation marks are calibrated against a Sine Bar or an Electronic Inclinometer to ensure the actual angle matches the scale.
• Lateral Tilt (±45°): Often the most difficult to measure; it requires checking the compound angle accuracy using a 3D Coordinate Measuring Machine (CMM) or precision angle blocks.

3.Design & Structural Integrity
•Stress-Relieved Casting: The body is made of "seasoned" cast iron, meaning the metal has been aged to allow internal stresses to settle. This prevents the vice from warping or losing its precision over years of use.
• Precision-Ground Slides: The "ways" (the surfaces the movable jaw slides on) are ground to a mirror finish. This ensures smooth movement and prevents "jaw lift," where the jaw tilts upward when tightened.
•High-Tensile Lead Screw: The internal screw is typically made of alloy steel with a precision-cut ACME thread, providing high clamping force with minimal effort from the operator.

•Hardened Jaws: Beyond just being hard (55 HRC), the jaws are often replaceable, allowing the user to swap them for soft jaws or V-jaws for holding round stock.

4.Advanced Metrology & Accuracy
• Zero-Point Alignment: High-end models feature a "zero" notch or pin that allows the user to quickly return the vice to a perfectly level, 90-degree position without re-measuring every time.
• Vernier Scales: Some super-precision models include a Vernier scale on the swivel base, allowing for angular adjustments down to minutes of a degree (1/60th of a degree) rather than just whole degrees.
• Squareness of Base to Jaws: A critical metrology point is that the vertical face of the jaws must be perfectly square to the bottom of the base within 0.01 mm per 100 mm.

5.Operational Efficiency
•One-Time Setup: Its "Universal" nature allows for compound angle machining. You can set a tilt and a swivel simultaneously, which would otherwise require multiple setups or custom angled blocks.
• Vibration Damping: The mass of the seasoned cast iron naturally absorbs the harmonic vibrations produced by cutting tools, resulting in a better surface finish on the workpiece.
•Compact Footprint: Despite having three axes of movement, these vices are designed with a low profile to maximize the "Z-axis" (vertical) workspace available on smaller milling machines or grinders.

6.Maintenance & Longevity
• Lubrication Ports: Precision vices often feature dedicated oil or grease nipples to ensure the lead screw and swivel bearings remain lubricated and free of fine metal "swarf" (chips).
• Wiper Seals: Some models include felt or rubber wipers on the sliding jaws to prevent grinding dust from getting into the precision-ground internal mechanisms.
• Corrosion Resistance: The non-working surfaces are usually chemically blackened (phosphated) or painted to prevent rust, which could otherwise compromise the fit of the swivel joints.

5. Present Theory and Practices :

Features:

•The most versatile of all machine vices with all degrees of freedom, the Universal Vice allows the work piece to be set at any desired angle.

•The specific advantage of this Vice is its ability to be set perpendicular to the base, thereby allowing right angle machining on the same machine setting
•Allows for the job to be set at low heights, particularly suitable for the most complicated grinding applications.

•Fully graduated 360° swivel base allows complete rotation along the vertical axis. The third angular side with a moving axis allows for any setting in the 3D plane.

•Sliding jaw runs on accurately ground surfaces fitted with hardened steel keep strips ensuring perfect alignment and rigidity.

• All swivelling movements have positive locking.

• A milled slot in the vice base allows for accurate location of the vice on the machine table using rectangular locating nuts.

• Hold Down" Slots allow for secure clamping of the vice on the work table.

• Specially designed for surface grinders and Universal tool and Cutter grinders
.
• Workpiece can be positively locked on hardened Jaws, at any compound Angle.

6. Construction:

• Vise Body made of High tensile close grain seasoned Cast Iron by casting.

• S.G.Ductile Iron Frame

• Jaw Plates are ground and Hardened to 50-60 HRC.

• Jaw plates are hardened steel with accurately ground surface.

• Use of hi tensile grade 10.8 fasteners provides strength and rigidity to these vices.

• Vise top surface is ground accurately to facilitate use of magnetic tool holders and other accessories.

• Supplied complete with steel handle.

• Vices have a premium polychromatic finish.

• It is assembled on the spindle crank with a spring loaded mechanism providing positive grip.

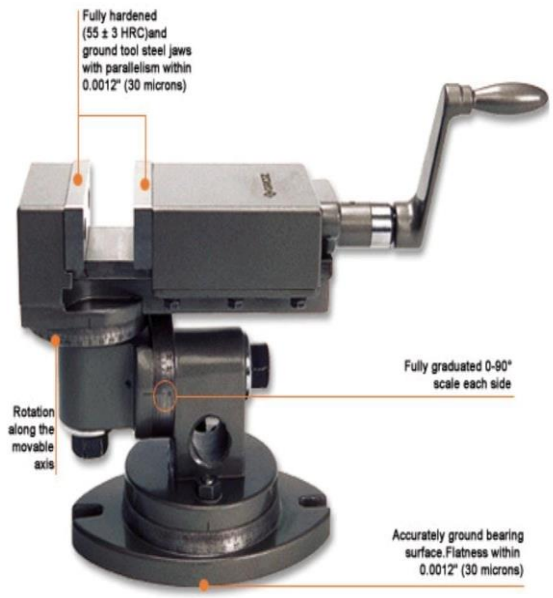
•The process flow is as under:

1. Milling
2. Drilling
3. Tapping
4. Grinding/ Machining (screws and nuts)
5. Milling square on shanks
6. Inspection

7. Machine Specifications:

Item Code No.	Overall Height		Jaw Width		Jaw Depth		Jaw Opening	
	Inch	MM	Inch	MM	Inch	MM	Inch	MM
ABM-VC-4858	8-3/4	220	6	150	1-5/8	40	4-1/2	113

Weight – 60 lbs or 20 kg



8. ADVANTAGES & DISADVANTAGES :

Advantages :
1.Idle time of the machine is reduced.

2.It consumes less time for clamping and unclamping the job.

3.It reduces the manual labour.

4.Production rate increases.

Disadvantages:
1.Initial higher cost.

2.Required skilled labour.

3.Machine handling is very careful.

9. RESULT

The core result of implementing a Precision Universal Angle Vise is the achievement of highly accurate, multi-axis workholding that allows a workpiece to be set at any desired angle in a 3D plane without the need for multiple clampings. By utilizing its 360° horizontal swivel and 45° to 90° vertical tilting capabilities, users can perform complex grinding, milling, and drilling operations with a consistent parallelism and flatness tolerance often held within 0.0012" (30 microns). The use of fully hardened tool steel jaws (typically 55 ± 3 HRC) ensures the vise maintains its accuracy and rigidity under high cutting forces, effectively dampening vibrations that would otherwise lead to dimensional errors or poor surface finishes. Ultimately, this precision result translates to significant time and cost savings by streamlining setups for intricate parts in mold-making, die work, and tool-and-cutter grinding, while simultaneously improving operator safety and extending tool life through superior stability.

10. CONCLUSION

The Precision Universal Angle Vise serves as a critical asset for high-end machining by providing a stable, multi-axis platform that bridges the gap between standard work-holding and complex 3D positioning. By integrating a 360° horizontal swivel with a 90° vertical tilt, it allows for the precise orientation of workpieces in a single setup, which effectively eliminates cumulative alignment errors and drastically reduces labor time. The use of hardened tool steel jaws and high-tensile cast iron ensures that the vise maintains its rigorous tolerances—often within 0.0012" (30 microns)—even under the heavy pressures of grinding and milling. Ultimately, this tool is the definitive solution for tool-and-die makers and precision engineers who require maximum versatility without sacrificing the rigidity and accuracy necessary for professional-grade results.

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