How to square a block on a milling machine

This procedure explains how to square a block on a milling machine, starting from a rough sawn piece of material such as aluminum. You machine one reference surface first, then machine each remaining surface square to the ones before it. You label each surface as you go, measure the part, and finish with a squared workpiece ready for further machining.

Purpose

This procedure gives you a repeatable way to square up rough sawn stock before you machine the actual part. When it is complete, the workpiece has a flat reference surface and the other surfaces are machined at 90 degrees to it.

Scope

This procedure covers squaring a small rough sawn block, such as aluminum, in a milling machine vise. It covers:

- machining the reference surface and the surfaces square to it
- marking surfaces so you can track progress
- seating the part on a parallel
- measuring the part with a digital caliper
- checking squareness with a machinist's square

It does not cover final part machining after the block is squared.

Required equipment and PPE

Gather the following within reach of the milling machine before you start:

- Milling machine with a vise (solid jaw and movable jaw) and a milling cutter
- Rough sawn stock, such as an aluminum block
- Parallel
- Aluminum welding rod or aluminum wire (or another soft material such as wood) to place between the movable jaw and the rough surface
- Ball peen hammer
- Marker or scribe for labeling surfaces

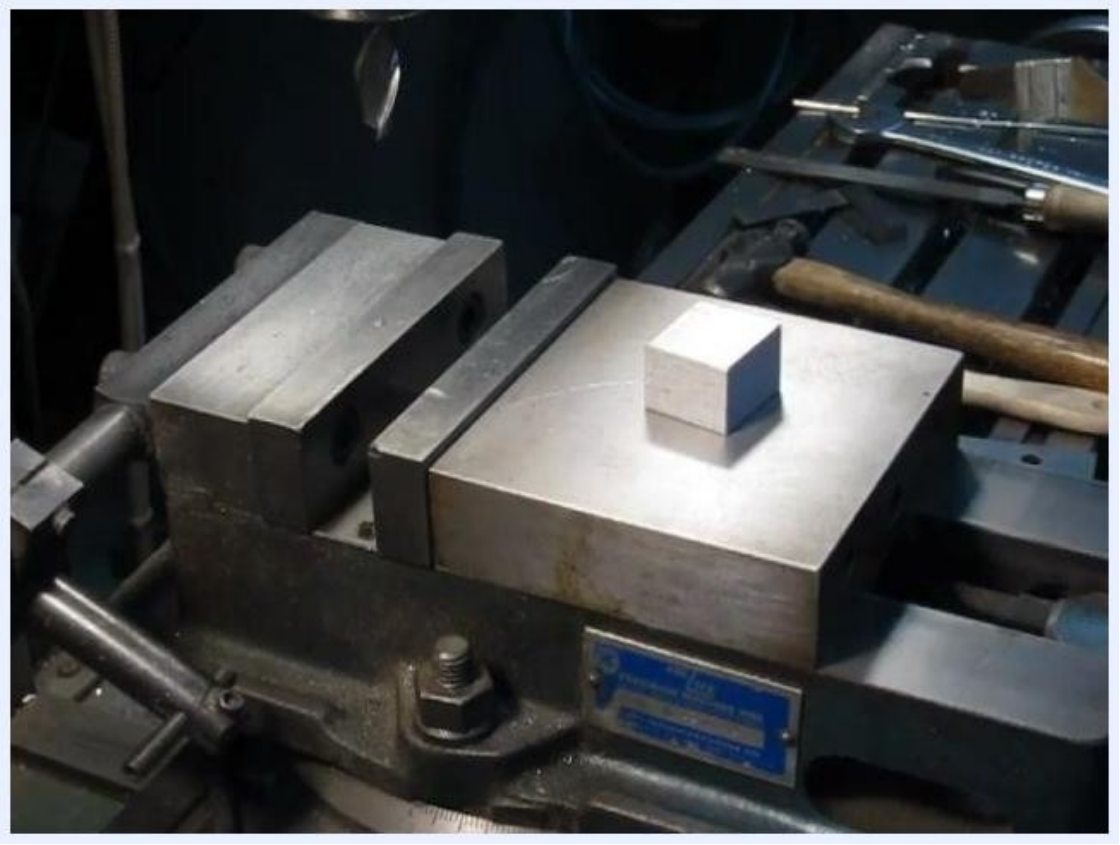
- Digital caliper (a micrometer can also be used to check dimensions)
- Solid square or machinist's square
- Brush for the work area

No personal protective equipment is specified for this procedure.

Procedure

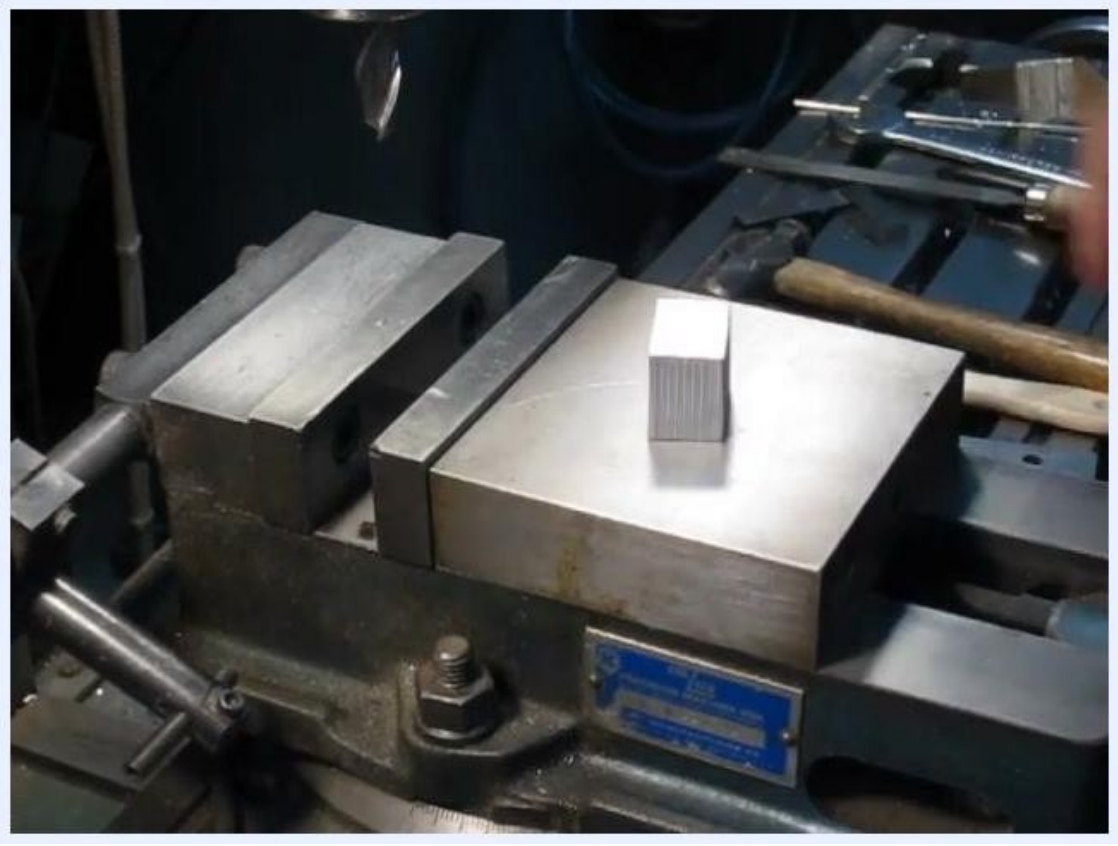
Part 1: Machine the reference surface (Surface 1)

1. Place the rough sawn stock on the milling machine in the vise. Make sure the work area is clear and that the parallels, welding rod, hammer, and other tools are within reach.



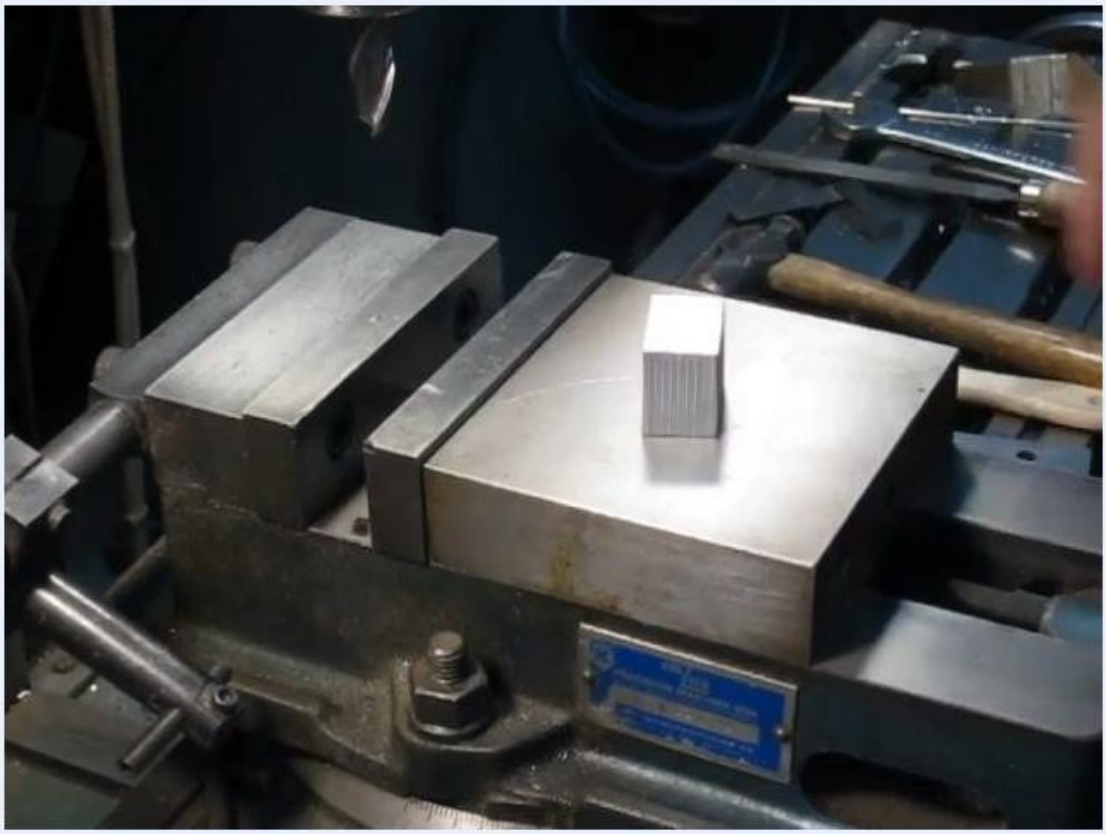
A rough sawn aluminum block sits on the open vise of a milling machine, with tools on the machine table.

2. Select the largest, flattest side of the stock as your reference surface. Hold the block and inspect it for the largest, most stable face.



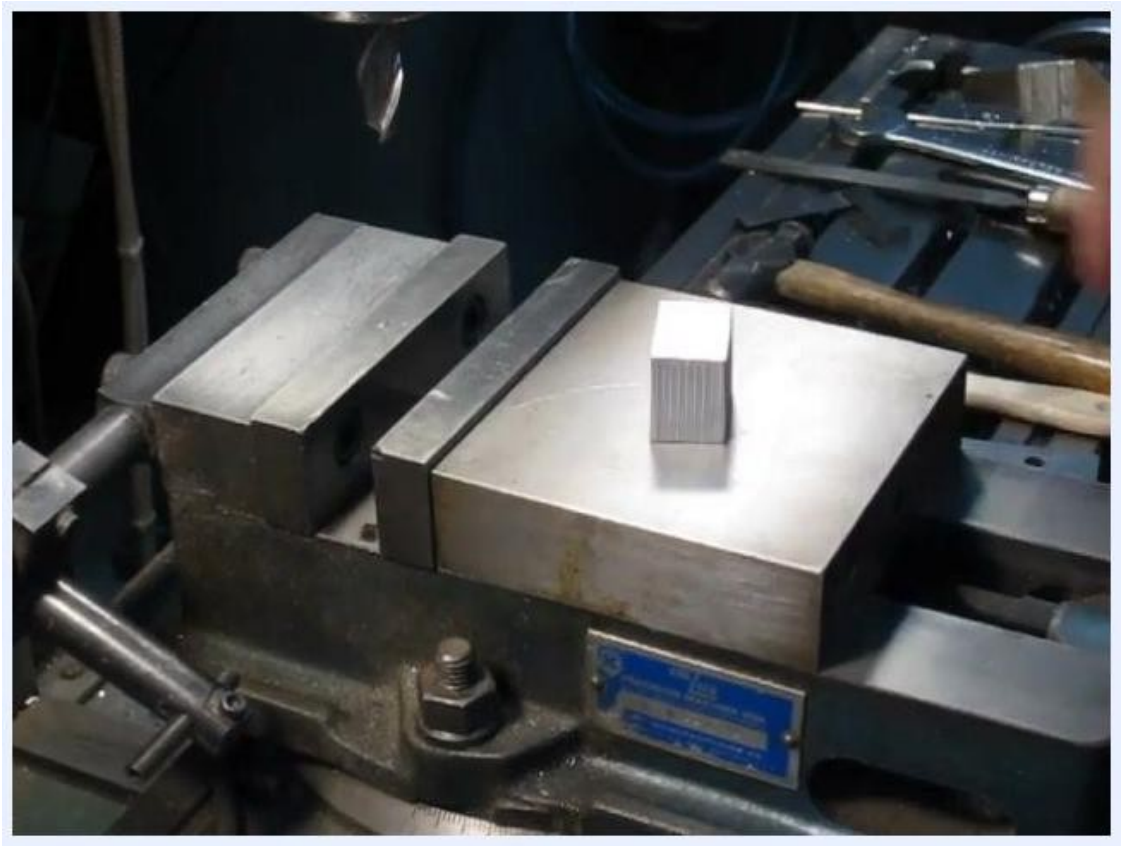
A hand holds the rough sawn aluminum block above the vise to select the reference surface.

3. Orient the block so the chosen reference face points upward. The largest side is the side you machine first.



The aluminum block is positioned upright on the vise with the reference face up.

4. Hold the block above the vise and insert a parallel underneath it. The parallel ensures the block sits level and is fully supported.



A hand holds the aluminum block above the vise while a parallel is placed underneath.

5. Set the block on top of the parallel. Make sure the parallel is flat and the block sits securely on it.



The aluminum block rests on a parallel inside the vise, ready for clamping.

6. Place a piece of aluminum welding rod between the movable jaw of the vise and the rough sawn surface of the part. The rod compensates for irregularities in the rough surface and gives even clamping pressure.



The aluminum block is in the vise with a parallel underneath and a welding rod between the movable jaw and the block.

7. Clamp the workpiece securely in the vise. Tighten the vise so the block is held firmly.

> **Safety note:** Do not overtighten the vise. Overtightening can distort the part.

8. Lower the milling cutter to the surface of the block and begin machining the top surface. Remove only as much material as you need to achieve a flat, clean surface.



The milling cutter is engaged with the top surface of the aluminum block, machining the reference face.

9. Continue machining until the entire reference surface is flat and smooth. Monitor the cut so you do not remove excess material, which could reduce the final part size below specification.



The milling cutter continues to machine the top surface of the aluminum block.

10. Stop the milling operation and raise the cutter. Inspect the newly machined surface for flatness and finish.



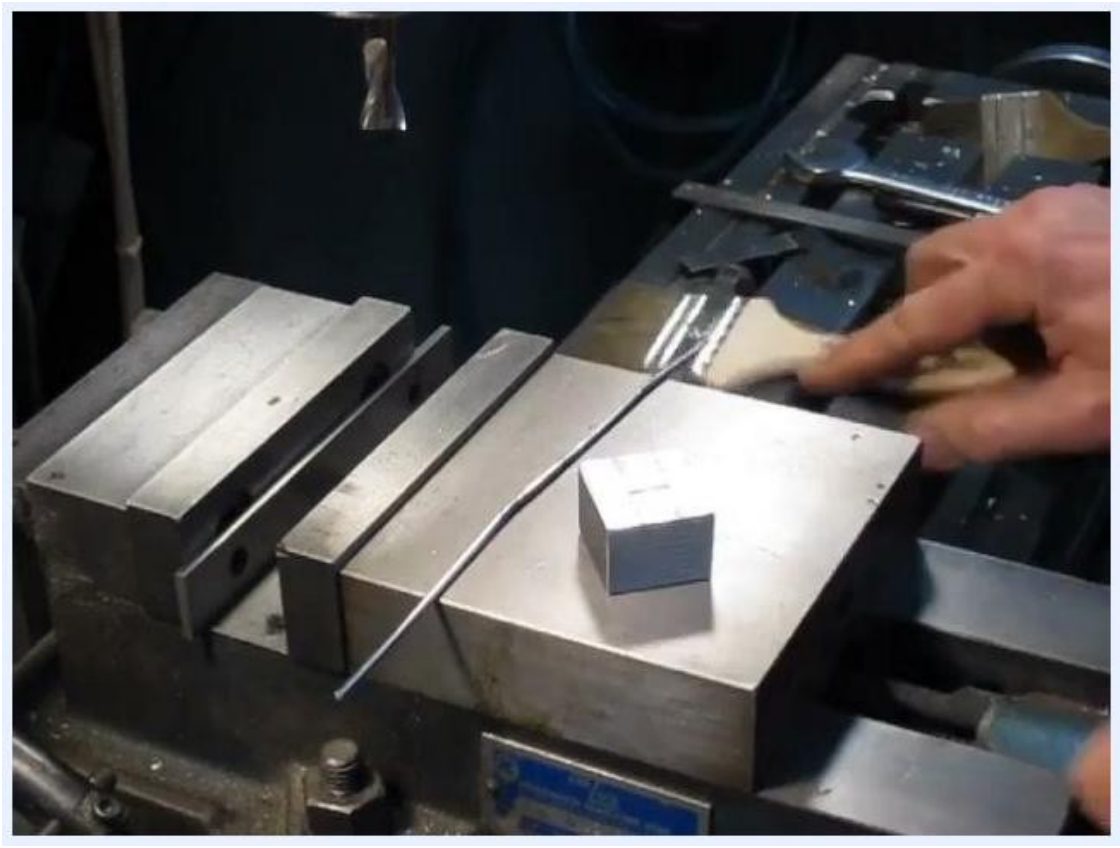
The aluminum block remains clamped in the vise with a freshly machined surface visible and the cutter raised.

11. Confirm that you have not removed more material than necessary. You need to preserve enough stock for the later machining steps.



The aluminum block is still in the vise, showing the completed reference surface with the parallel and welding rod in place.

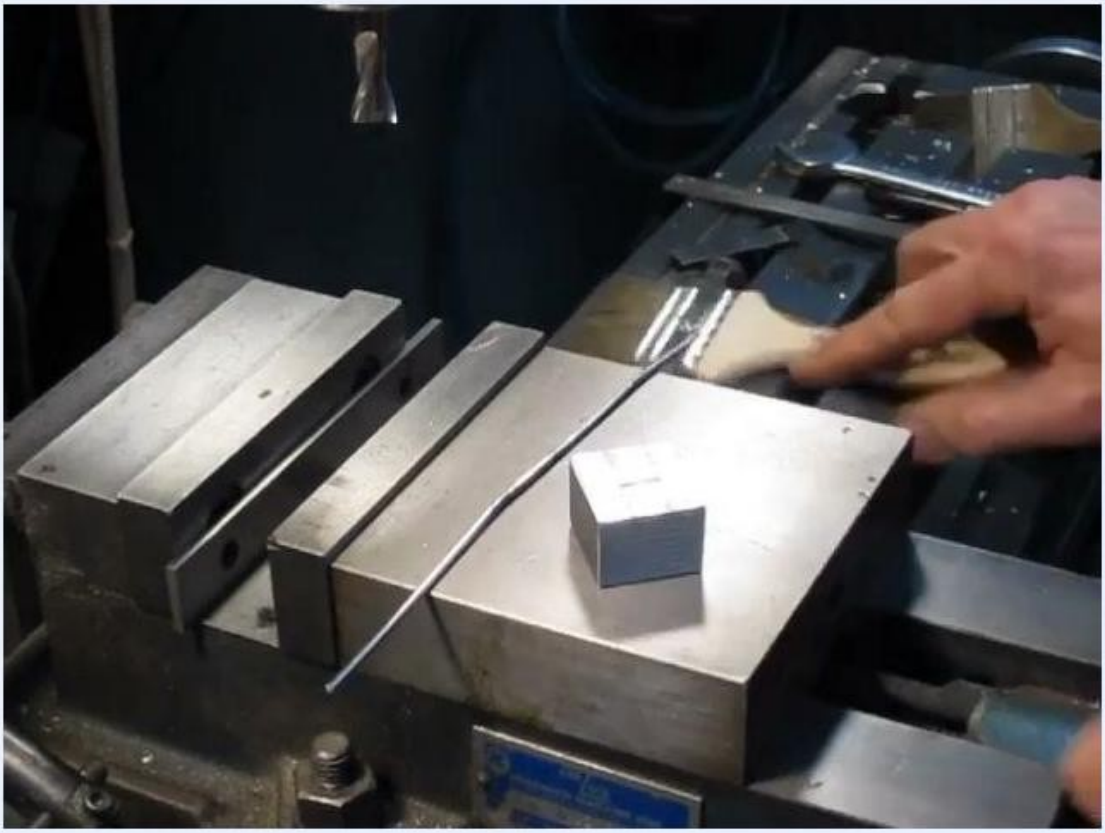
12. Mark the freshly machined reference surface as "Surface 1" with a marker or scribe. Place the block on the vise with the marked surface visible.



The aluminum block sits on the vise with a marked surface, surrounded by a welding rod, hammer, and brush.

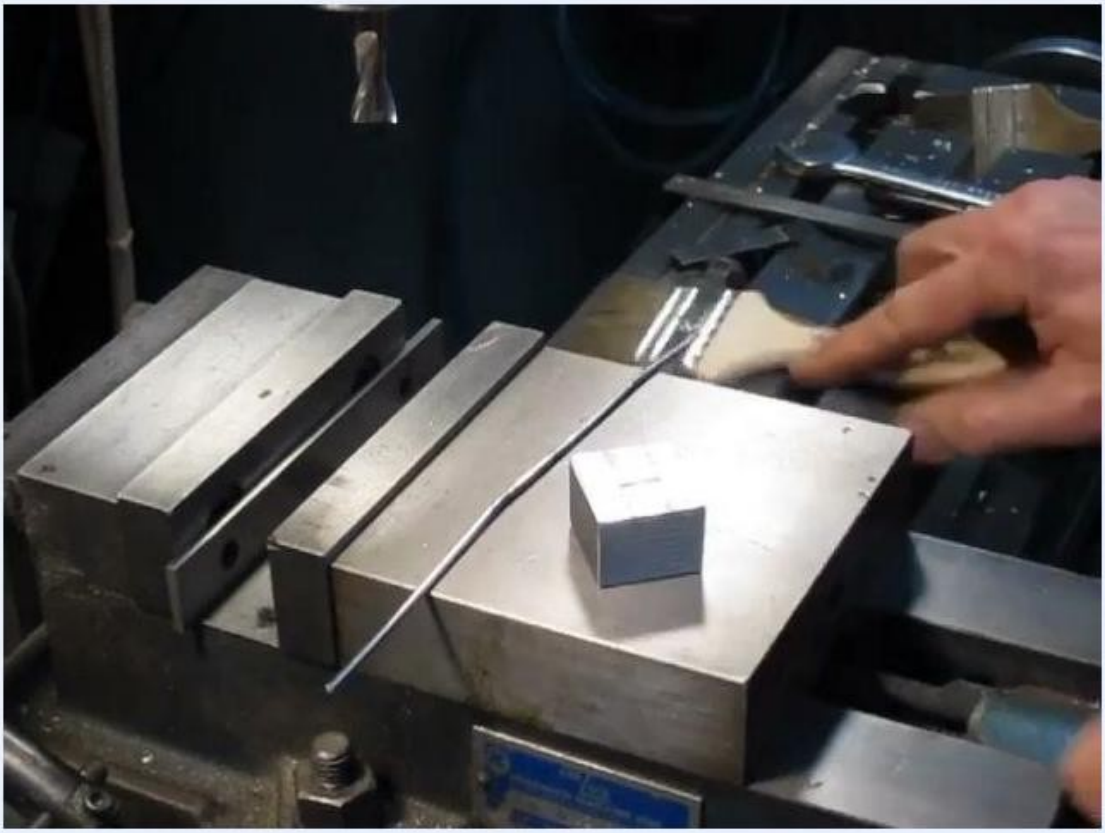
Part 2: Machine the second surface (Surface 2)

13. Prepare to machine a second surface at a right angle to Surface 1. Place Surface 1 against the solid jaw of the vise. Insert a soft material between the rough sawn surface and the movable jaw to ensure even clamping pressure. Aluminum wire or wood both work, so choose whichever is available in your workspace.



A hand reaches for a brush near the vise, with the aluminum block and aluminum wire on the machine table.

14. Clamp the workpiece in the vise with Surface 1 against the solid jaw and the aluminum wire between the movable jaw and the block. Make sure the block sits flat on the parallel and is held firmly.



The aluminum block is clamped in the vise with aluminum wire between the movable jaw and the block.

15. Lower the milling cutter to the exposed face of the block and machine the second surface. Remove just enough material to achieve a clean, flat surface at a right angle to Surface 1.



The milling cutter is engaged with the second surface of the clamped aluminum block.

16. Continue machining until the entire second surface is flat and smooth. Monitor the cut to avoid removing excess material.



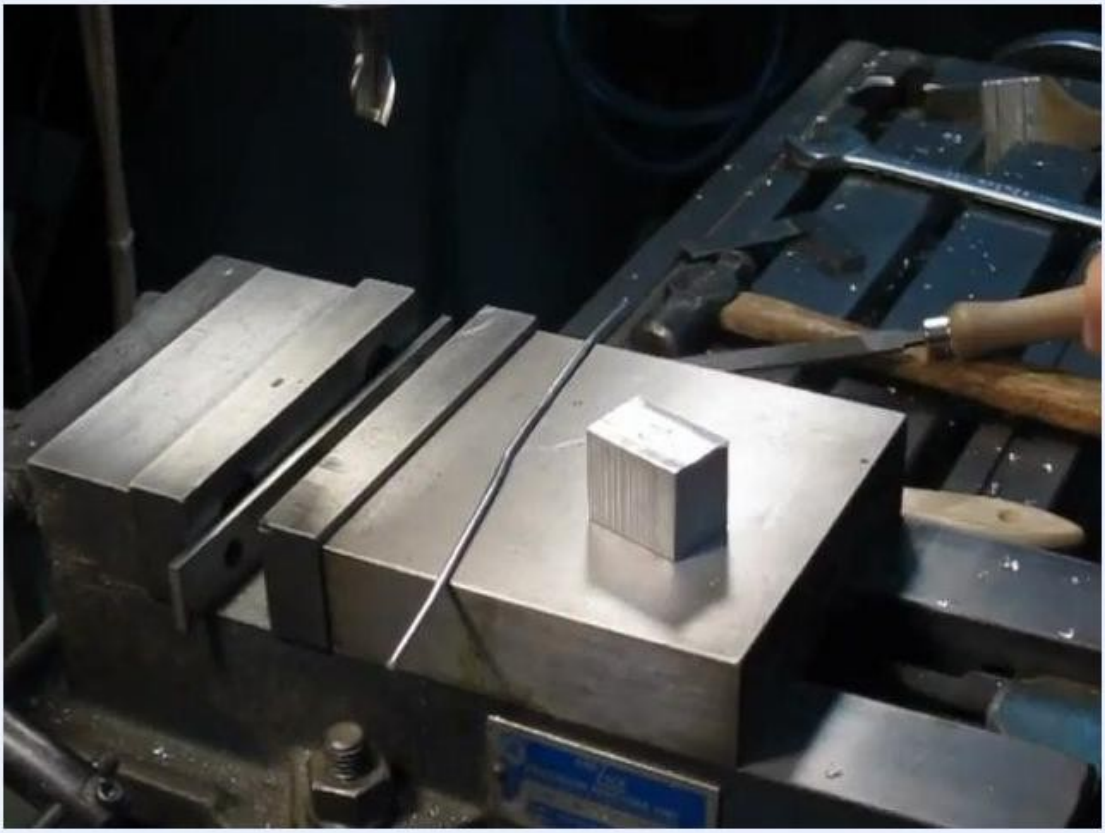
The milling cutter continues to machine the second surface of the aluminum block.

17. Stop the milling operation and raise the cutter. Inspect the newly machined surface for flatness and finish.



The aluminum block remains clamped in the vise with two machined surfaces visible and the cutter raised.

18. Remove the block from the vise and mark the second machined surface as "Surface 2" with a marker or scribe.

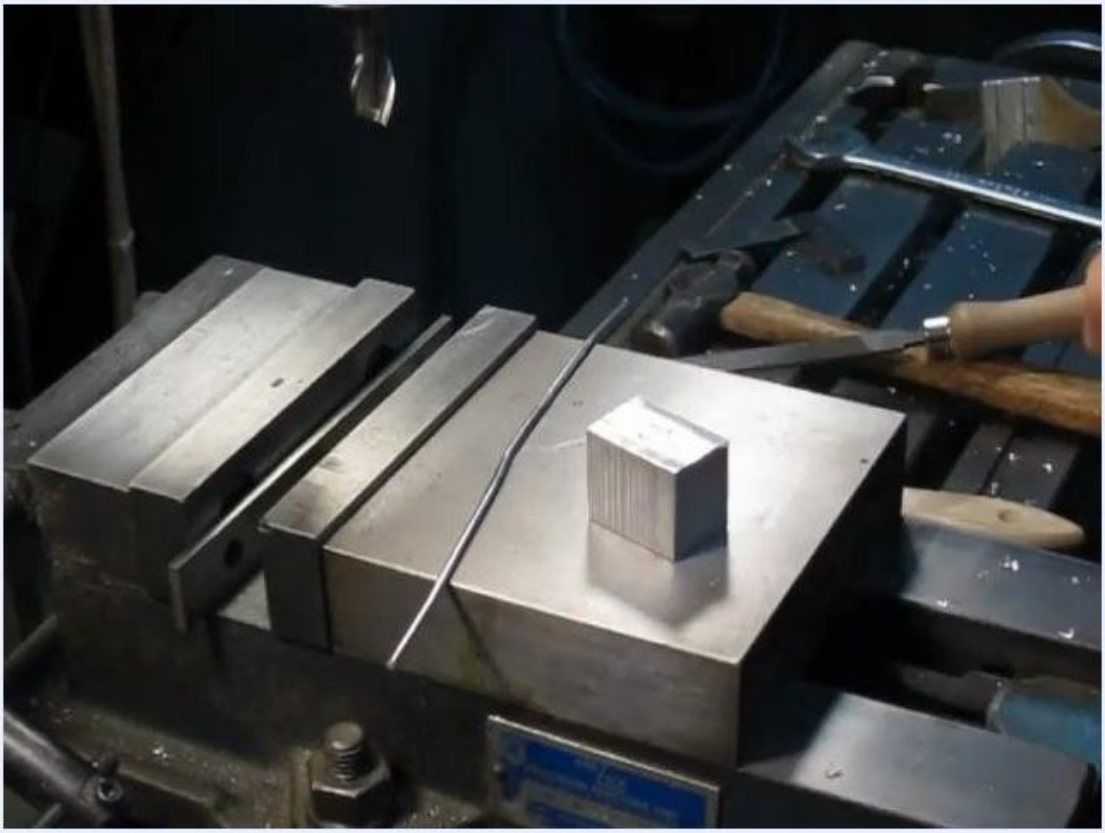


The aluminum block is removed from the vise, and a hand prepares to mark the second machined surface.

At this point, you have two adjacent, flat surfaces, each clearly marked for identification during later operations.

Part 3: Machine the third surface and check the thickness

19. Prepare to machine the surface opposite Surface 2. Keep Surface 1 against the solid jaw of the vise. Rotate the part so Surface 2 faces down against the parallel, and make sure the block is properly oriented for the next operation.



A hand holds the aluminum block, showing two machined and marked surfaces, before repositioning it in the vise.

20. Place the workpiece in the vise with the newly machined surface facing down against the parallel. Confirm that Surface 1 is still against the solid jaw. Insert the aluminum wire (or other soft material) between the rough sawn surface and the movable jaw to maintain even clamping pressure.



A hand positions the aluminum block in the vise with the machined surface down on the parallel and the aluminum wire in place.

21. Tap the block down onto the parallel with a ball peen hammer. Hold the part gently while you tap so you can feel when it sets solidly on the parallel. This seats the block flat so it machines accurately.



The block is clamped in the vise with the aluminum wire in place, and a hammer is on the table ready for tapping.

22. Confirm the block is firmly seated on the parallel. Tap gently and feel for a solid set, which indicates the block is flat and secure.



The block remains clamped in the vise with the aluminum wire after being tapped down.

23. Lower the milling cutter to the exposed face of the block and machine the surface. Remove just enough material to achieve a clean, flat surface at a right angle to the previously machined surfaces.



The milling cutter is engaged with the exposed surface of the aluminum block clamped in the vise.

24. Continue machining until the entire surface is flat and smooth. Monitor the cut to avoid removing excess material.



The milling cutter continues to machine the surface of the aluminum block to a flat finish.

25. Raise the cutter and inspect the workpiece. Confirm that you now have your original reference surface and two other surfaces machined at right angles to it.



The milling cutter is raised, and the block in the vise now has three machined surfaces.

26. Measure the dimension across the two finished surfaces with a digital caliper. In this example, the block measures 1.095 inches (1 inch 95 thousandths).



A digital caliper measures the thickness of the aluminum block, reading 1.095 inches.

27. If you need to remove more material to reach the desired dimension (for example, 1.000 inch), remove the block from the vise. Note the current measurement and plan how much material to remove.



The block is removed from the vise, showing the marked surfaces, ready for further machining if needed.

28. Reinsert the block into the vise for additional machining if required. Place the reference surface against the solid jaw and the aluminum wire between the rough surface and the movable jaw. Tap the block down onto the parallel to seat it flat.



A hand places the block back into the vise, positioning it for further machining.

29. Increase the cutting depth to 95 for the final finishing cut. In this example, the previous cut was taken to 85. Take one roughing cut followed by one finishing cut for best results.

> **Note:** If you need more than two cuts, check whether you left too much stock on the part.



The milling machine performs a finishing cut on a workpiece clamped in the vise, with metal chips on the vise and table.

30. Complete the finishing cut and retract the cutter. Remove the workpiece from the vise, leaving only the parallel in the vise. Confirm that you have your original reference surface and two other surfaces at 90 degrees to it.

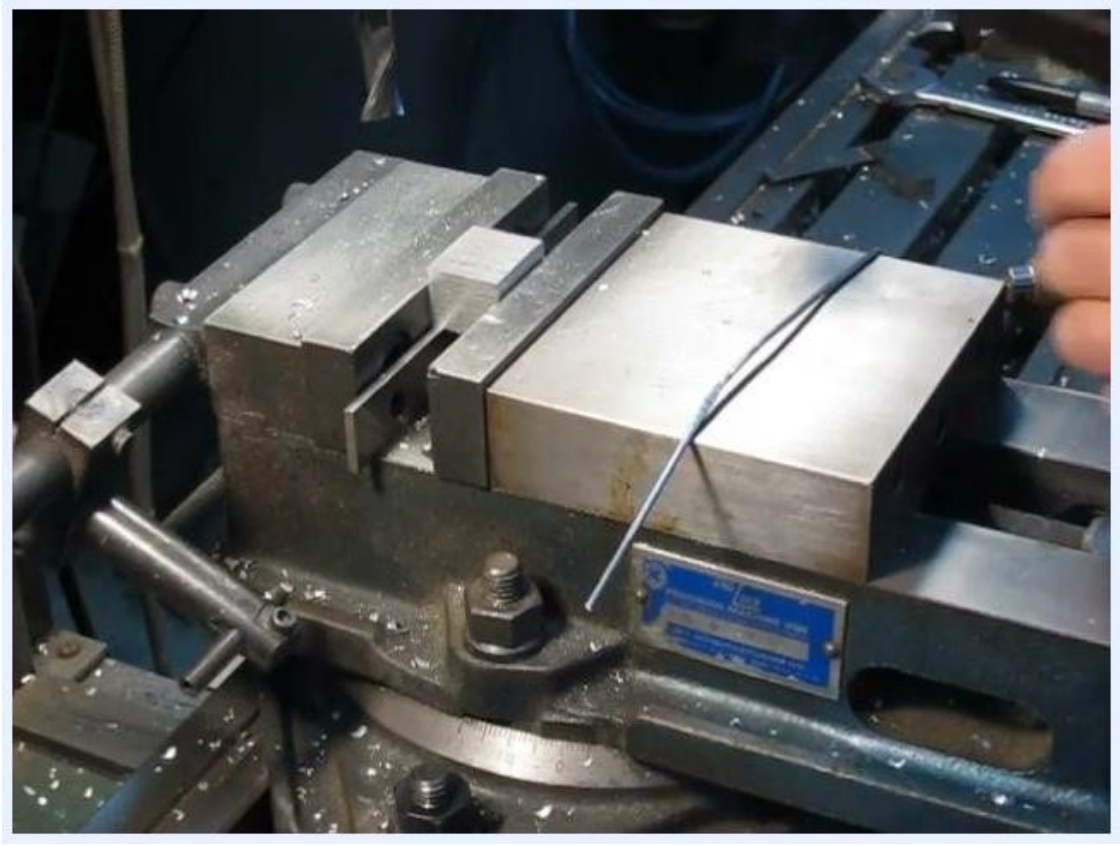
31. Note that this setup uses only one parallel in the vise because the part is small.



The operator holds the small machined workpiece above the vise, with a single parallel visible in the vise.

32. Prepare for the next operation by placing the original reference surface of the workpiece down against the parallel.

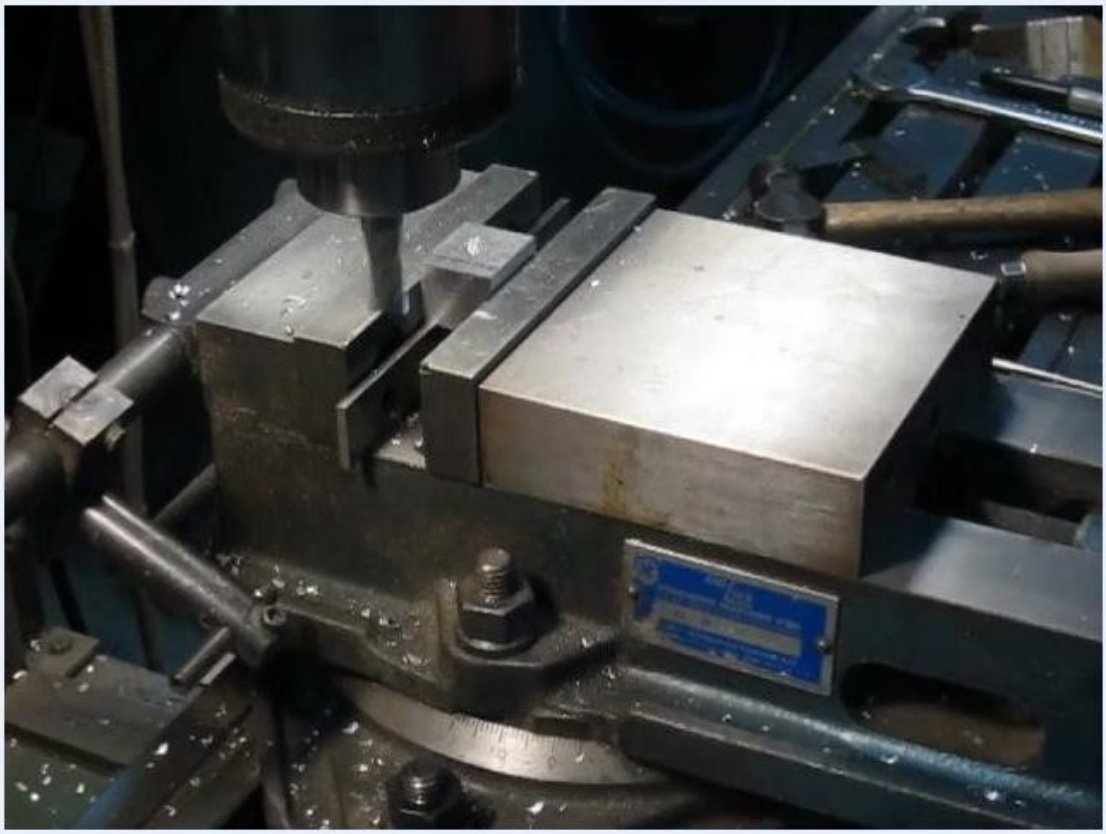
33. Make sure the machined surface faces down on the parallel, clamp the workpiece, and tap it to seat it firmly. You tap because a machined surface is again down against the parallel.



The workpiece is clamped in the vise with the machined surface down on the parallel while the operator seats it.

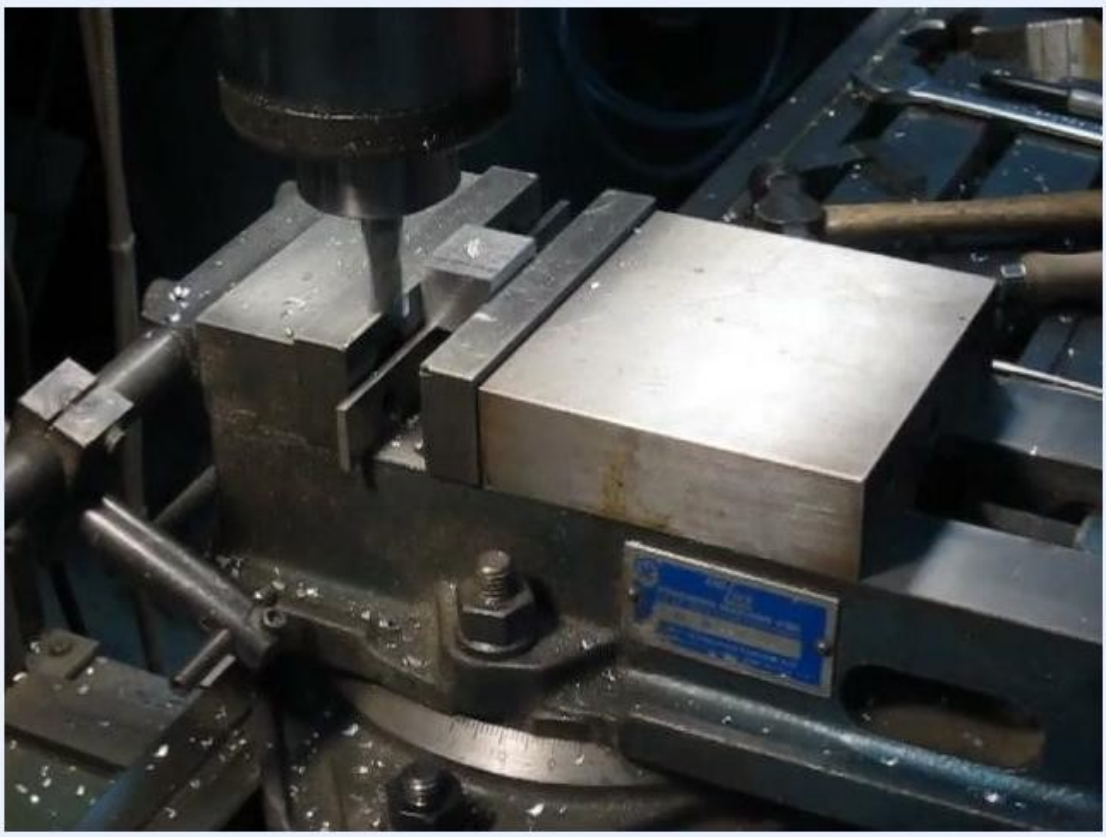
Part 4: Machine the fourth surface

34. Prepare to clean up the next surface. Make sure the workpiece is clamped in the vise with the machined reference surface down on the parallel. Position the milling cutter above the workpiece.



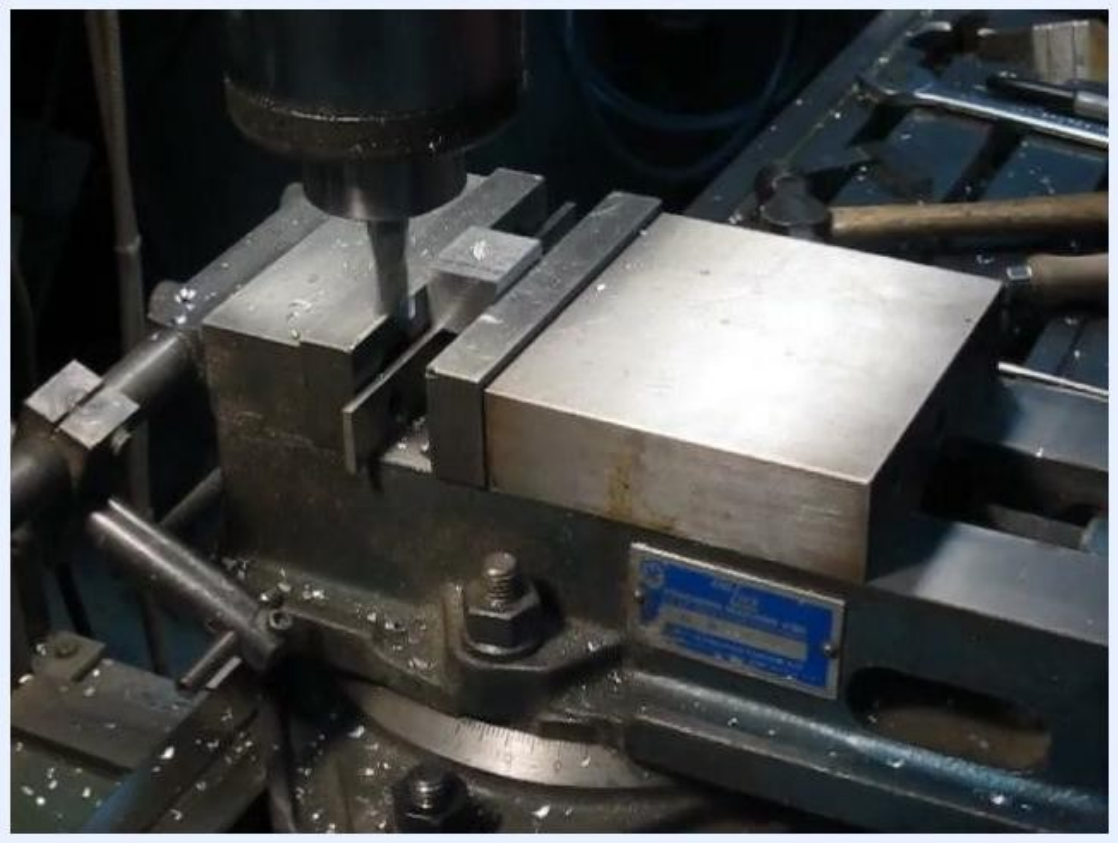
The workpiece is clamped in the vise with the milling cutter positioned above the next surface to be machined.

35. Machine the surface. To bring it to a precise finished size, measure the workpiece with a caliper or micrometer and move the milling table up by the required amount. Then cut the surface again. In this example, this sizing step is skipped to save time.



The milling cutter is engaged with the workpiece, performing a machining pass.

36. Retract the cutter after the machining pass. The freshly machined surface is now visible, and the workpiece remains clamped in the vise.



The milling cutter is retracted above the workpiece, and the machined surface is visible.

37. Loosen the vise and lift the workpiece out to prepare for the last two surfaces.



The operator's hand lifts the workpiece out of the open vise.

38. Take your solid square and set it on the parallel. Position the workpiece upright in the vise, resting on the parallel.



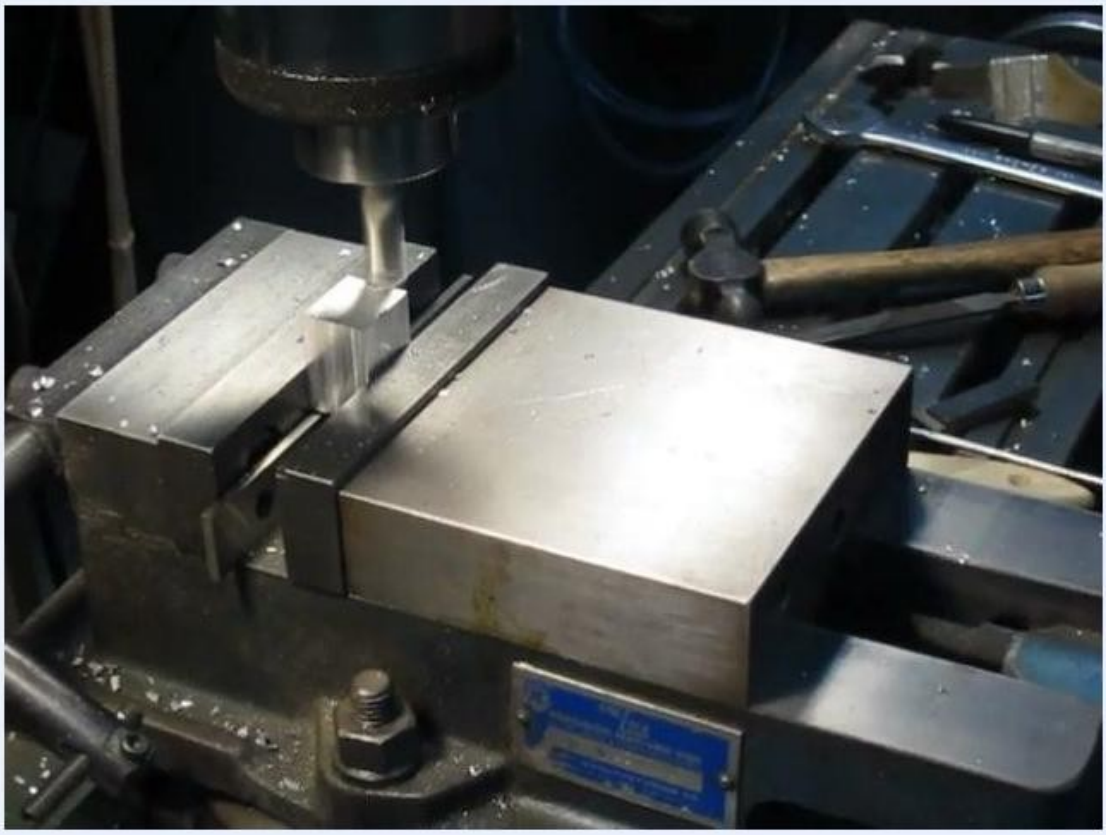
The workpiece is positioned upright in the vise, resting on the parallel.

39. Square up the workpiece off Surface 2, the second surface. Hold a machinist's square against the workpiece to check that it is perpendicular to the vise jaw. Adjust the workpiece as needed.



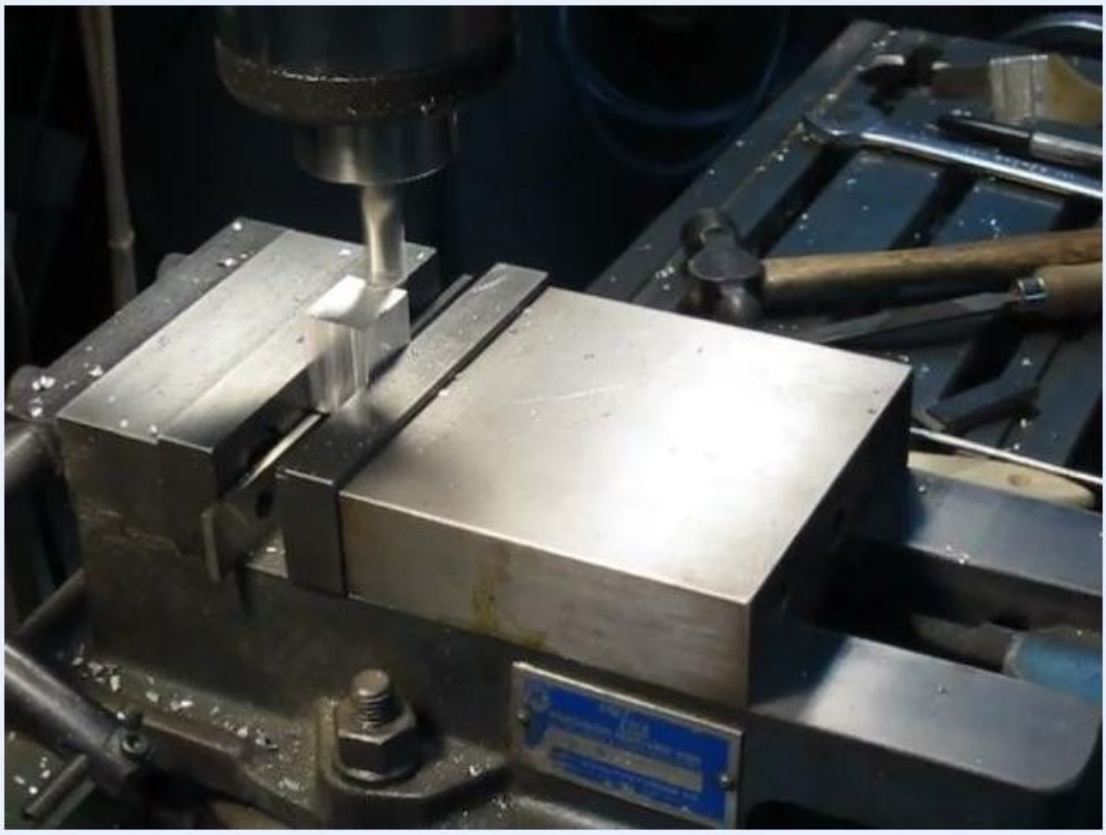
The operator uses a machinist's square to align the workpiece, referencing the second machined surface.

40. Confirm that the workpiece is square to the solid jaw of the vise. Double-check the alignment with the square.



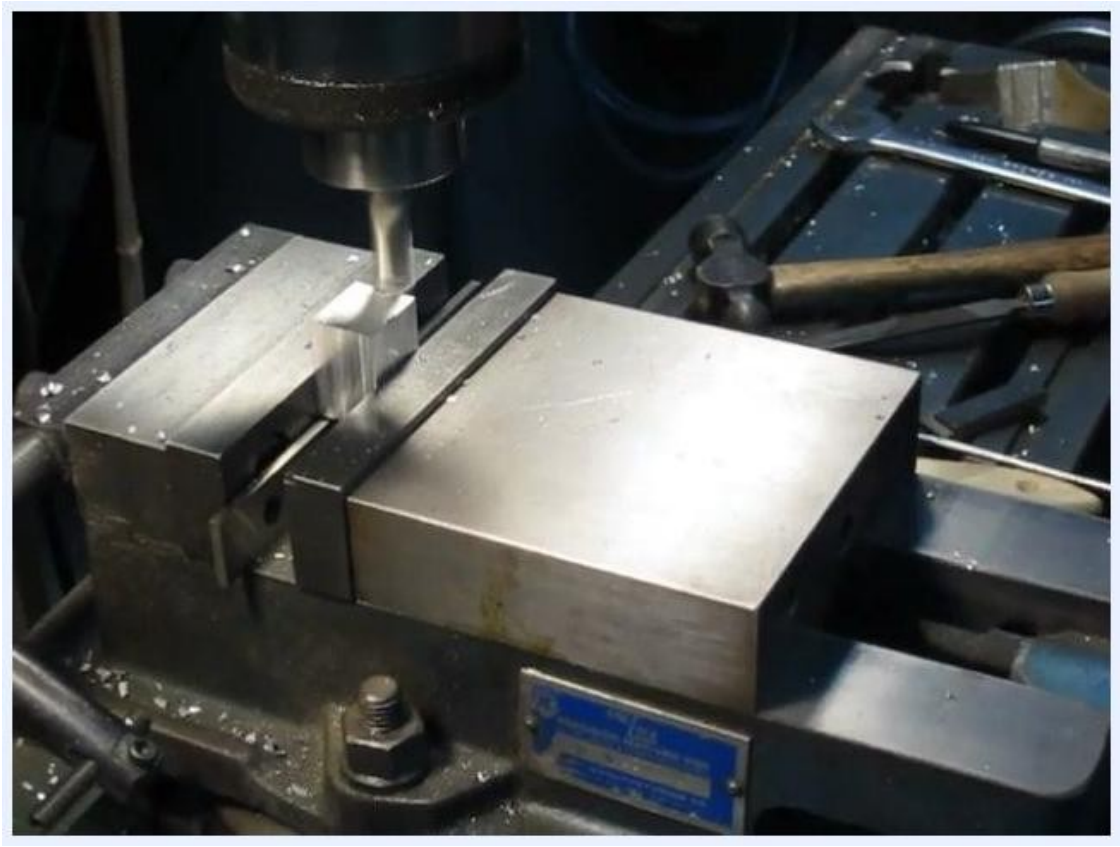
The operator's hand is above the workpiece, confirming squareness to the solid jaw.

41. Confirm that the workpiece is also square to the parallel. Verify that the bottom of the workpiece is seated flat on the parallel so you can machine the fourth surface.



The workpiece stands upright in the vise with the milling cutter above the fourth surface.

42. Lower the milling cutter and machine the fourth surface. Watch the cutter remove material while chips accumulate on the vise and table.



The milling cutter is engaged with the fourth surface of the workpiece.

Part 5: Machine the final surface and finish the squared block

43. Prepare to machine the final surface. Make sure the workpiece is clamped in the vise with the previously machined surfaces visible and the milling cutter positioned above it.



The workpiece is clamped in the vise with the milling cutter above and tools and chips on the machine table.

44. For the last surface, keep the original reference surface against the solid jaw of the vise. Remove the workpiece from the vise to reposition it.



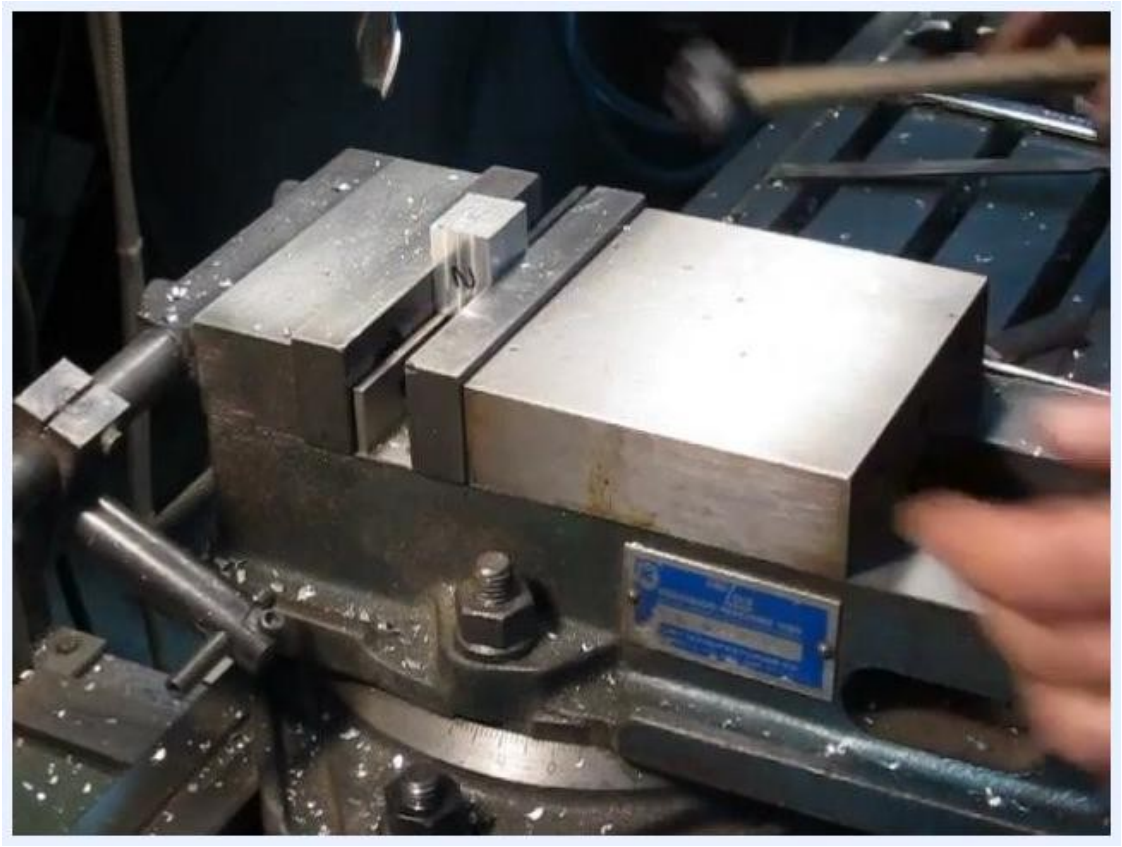
The operator's hand reaches toward the vise to reposition the workpiece.

45. Rotate the workpiece 180 degrees so the unmachined surface is exposed. Place the reference surface firmly against the solid jaw of the vise.



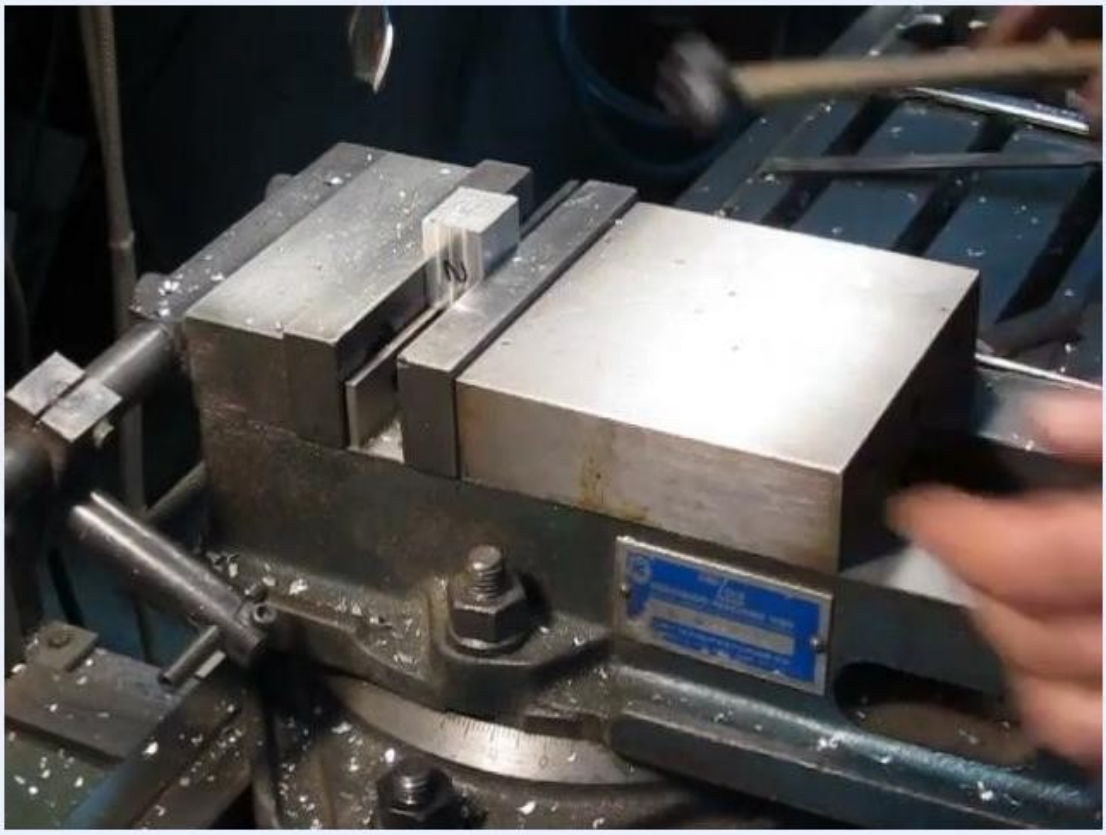
The operator holds the workpiece and rotates it 180 degrees above the vise.

46. Tap the top of the workpiece gently with a hammer to seat it flat on the parallel. Hold the workpiece in place while tapping.



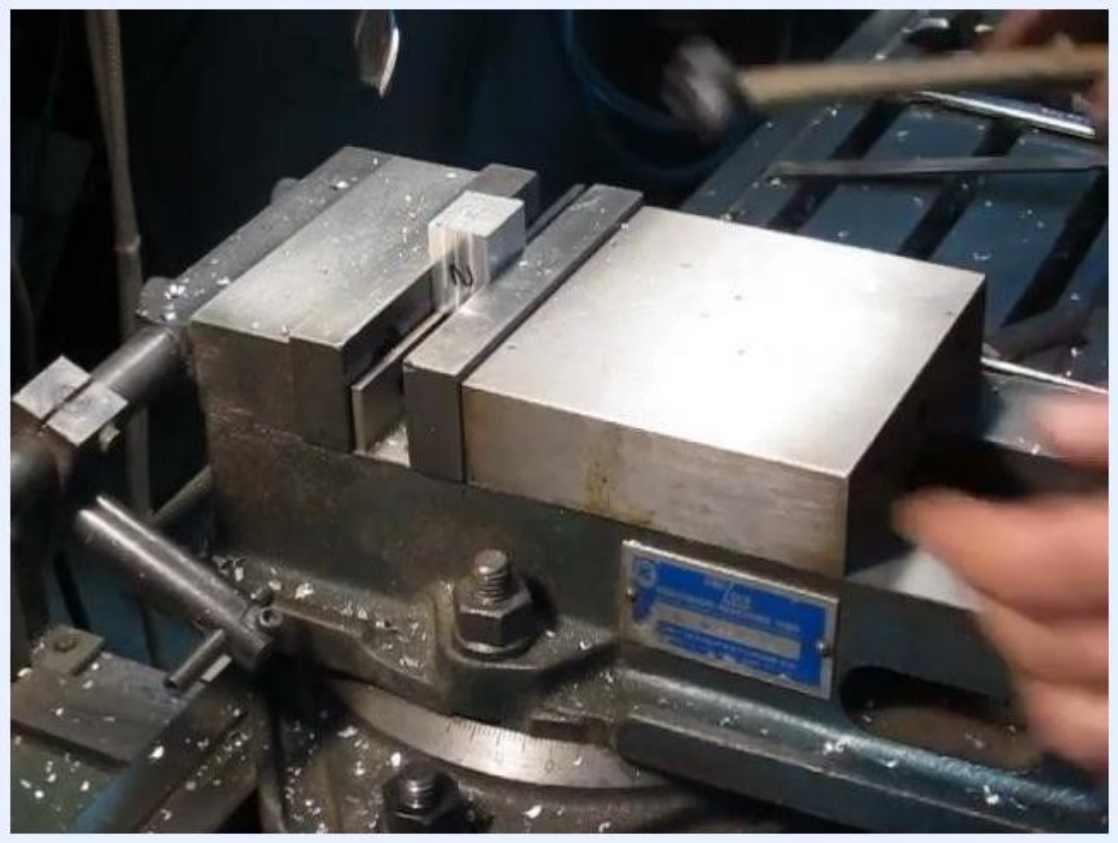
The operator holds the workpiece in the vise and taps it down with a hammer to seat it on the parallel.

47. Confirm the workpiece is properly seated and aligned. The reference surface sits against the solid jaw, and the unmachined surface is exposed.



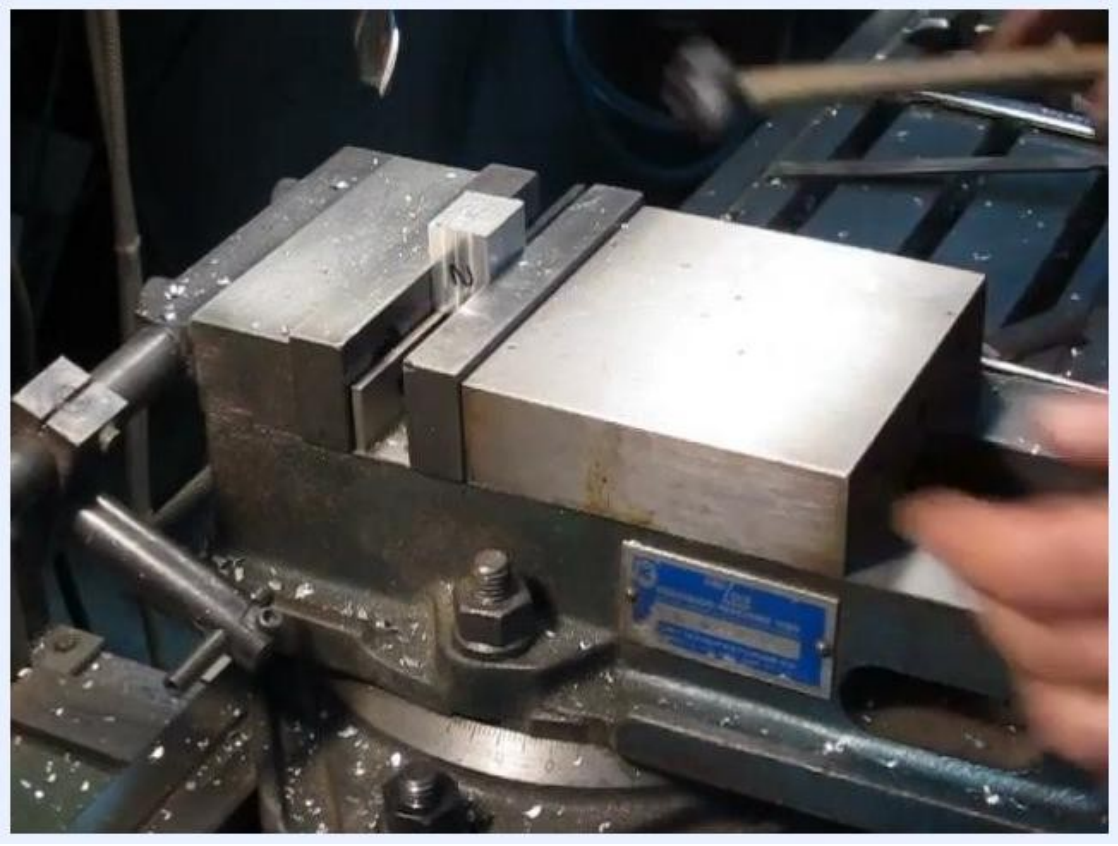
The workpiece is clamped in the vise with the operator's hand and hammer visible, confirming alignment.

48. Lower the milling cutter and machine the last exposed surface. Watch the cutter remove material while chips accumulate on the vise and table.



The milling cutter is engaged with the final surface of the workpiece.

49. Raise the milling cutter away from the workpiece and inspect it. The workpiece remains clamped in the vise with all surfaces now machined.



The milling cutter is retracted above the workpiece, which remains clamped in the vise.

50. Measure the dimensions of the last two machined surfaces with a caliper or micrometer.



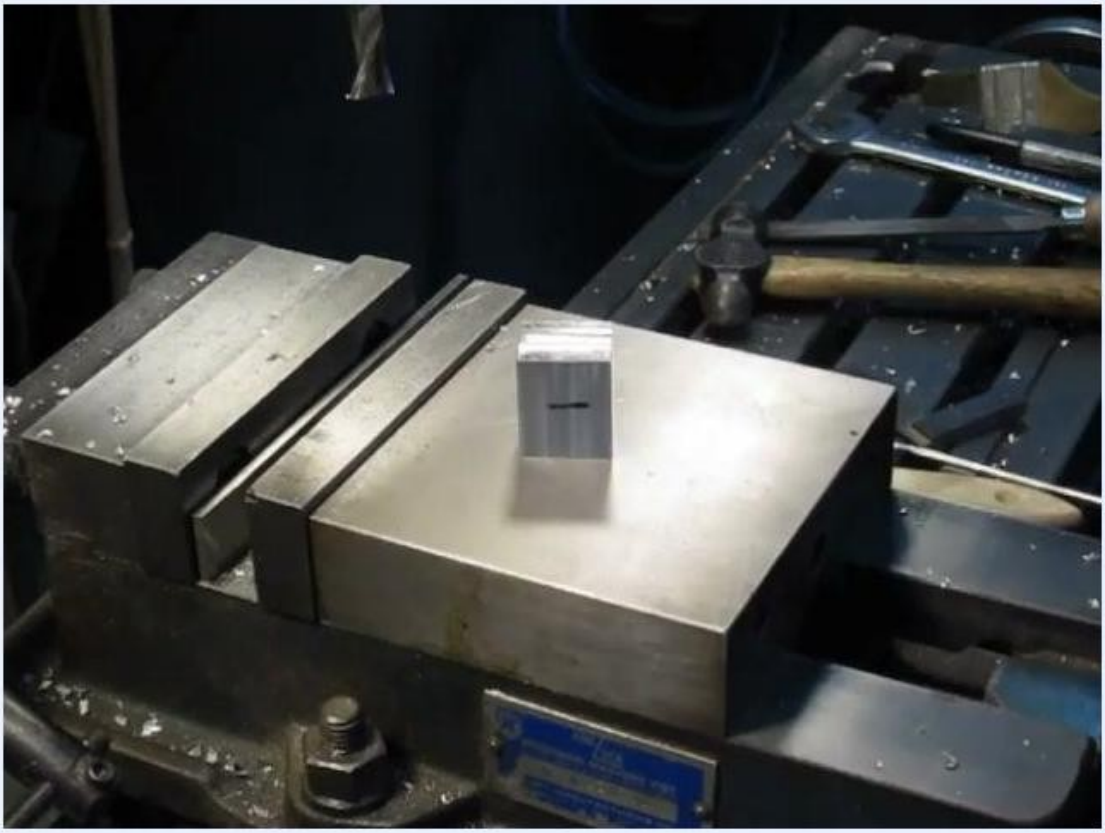
The operator uses a measuring tool to check the dimensions of the workpiece.

51. For a real part, move the table up by the required amount and take the workpiece down to the final size. In this example, this step is skipped because the goal is to show how to square up the part.



The operator holds a measuring tool, preparing to adjust or remove the workpiece.

52. Remove the finished, squared workpiece from the vise. Place it upright on the machine table for inspection.



The finished, squared workpiece stands upright on the machine table with tools and chips in the background.

Verification

Before you consider the block squared, confirm each of the following:

- Surface 1 is flat and smooth, and it was machined first from the largest, flattest side of the stock.
- Surface 2 is flat and at a right angle to Surface 1.
- The third surface is machined at a right angle to the previously machined surfaces.
- You can identify the original reference surface and the two surfaces machined at 90 degrees to it.
- The workpiece was square to the solid jaw of the vise and to the parallel before you machined the fourth surface.
- You measured the finished surfaces and, for a real part, took the workpiece down to final size.

Summary of key points

- Machine the reference surface first, and label each surface as you finish it.
- Use aluminum welding rod or wire between the movable jaw and the rough sawn surface for even clamping pressure.
- Do not overtighten the vise, and do not remove more material than necessary.
- Tap the workpiece down onto the parallel whenever a machined surface faces down.
- Take one roughing cut and one finishing cut. If you need more, check whether you left too much stock.
- Use a machinist's square to check squareness to the solid jaw and the parallel.
- Keep the original reference surface against the solid jaw for the final machining pass.

What's next

After you square a block on a milling machine, take the workpiece to its final dimensions by measuring each pair of surfaces and moving the table up by the required amount. Then continue with the machining of your actual part.