VERSA BUILT ROBOTICS

UR Mill Automation Kit
Machinist Manual

Table of Contents

Safety Warnings

DANGER: VersaBuilt makes industrial machine tool automation components designed to be operated by trained personnel only. Machine tool automation components may move suddenly and without warning. Serious or fatal crushing injuries can occur from contact with the robot, gripper or vises.

Before deploying VersaBuilt industrial machine tool automation components, a safety risk assessment must be completed in accordance with local, state and/or federal requirements.

VersaBuilt industrial machine tool automation components should only be used by trained operators.

Read and understand the VersaBuilt Mill Automation Kit Safety Manual before proceeding

Selecting Automatic vs Manual Mode

Section 2

Selecting Automatic vs Manual Mode

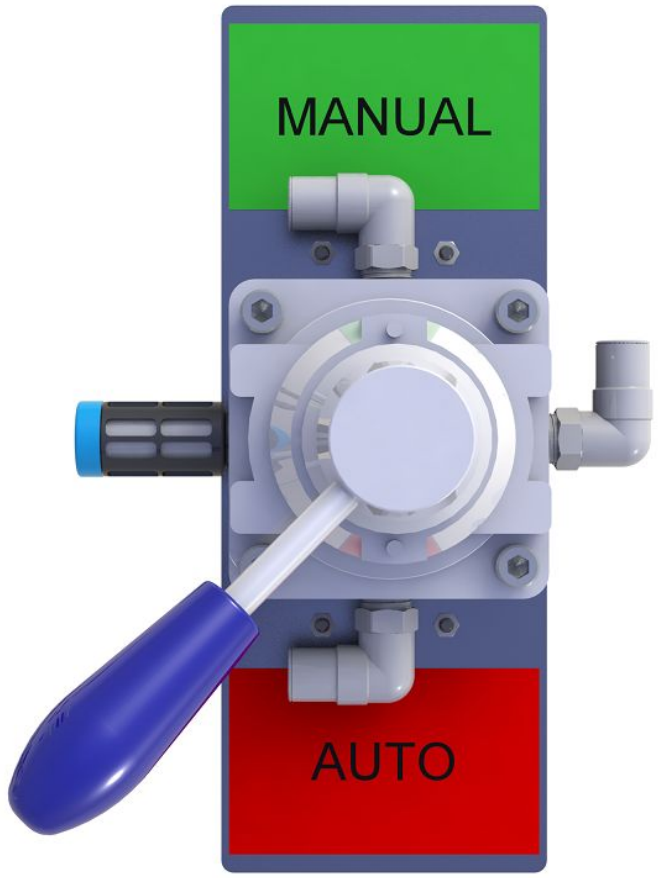
The Mill Automation Kit has 2 pneumatic modes: Auto and Manual

- Auto mode is for running parts in the CNC with robotic tending
- Manual mode is for running parts in the CNC via hand loading

When the system is in Auto Mode, air to the hand valves on the CNC table is blocked.

When the system is in Manual Mode, air to the VSC Mill Panel is blocked, disabling automatic functionality.

Switching between these 2 modes is done by way of the Diverter Valve and the Vise Hand Valves

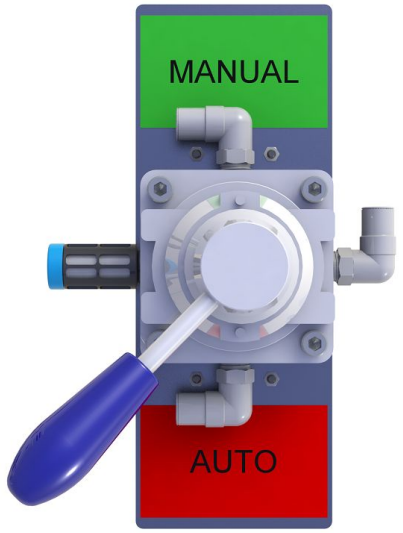


Diverter Valve shown in “Auto-Mode”

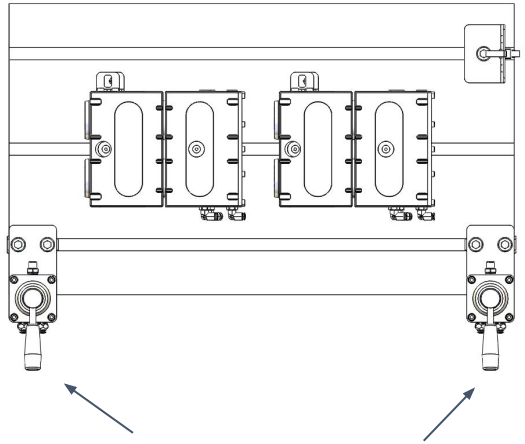
Selecting Pneumatic Automatic vs Manual Mode

Setting Automatic Mode:

1. Be prepared for sudden movement and keep all body parts away from the vises gripper, door opener and/or VersaBlast when moving the Diverter Valve switch
2. Set each Vise Hand Valve to the center position
3. Ensure all persons are clear of the vises, gripper, door opener and VersaBlast
4. Move the Diverter Valve handle to the AUTO position
5. From the VSC Recovery panel, verify the vises are opening and closing correctly



Diverter Valve shown in "Auto-Mode"

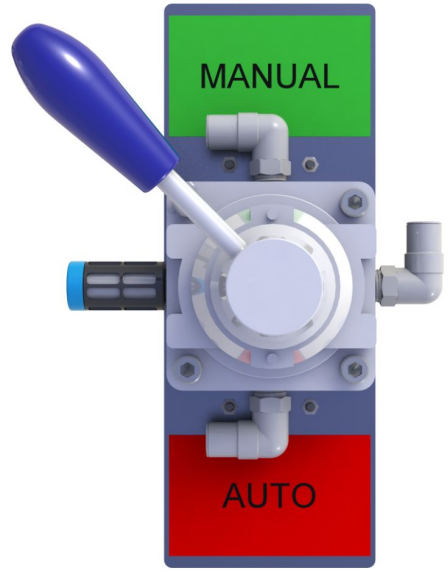


Vise Hand Valves shown in center position

Selecting Pneumatic Automatic vs Manual Mode

Setting Manual Mode:

1. Be prepared for sudden movement of the vises, gripper, door opener and/or VersaBlast
2. Ensure all persons are clear of the vises, gripper, door opener and VersaBlast
3. From the VSC Recovery panel, press the Float Vises button
4. Move the Diverter Valve handle to the MANUAL position
5. With ALL body parts clear of each vise, set each Vise Hand Valve away from the center position



Diverter Valve shown in “Manual-Mode”

Note: When MultiGrip OD Jaws are in the Robot Gripper and the diverter valve is shifted to Manual position, the Jaws will SPRING OPEN releasing any clamped material

Introduction to MultiGrip Jaws

Section 3

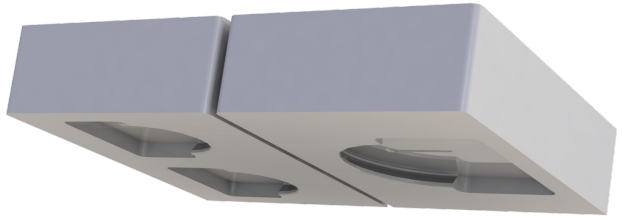
MultiGrip Introduction

MultiGrip Jaws consist of Left and Right 6061-T6 aluminum jaws with mating features for clamping parts, engaging a vise and interfacing with a robot gripper.

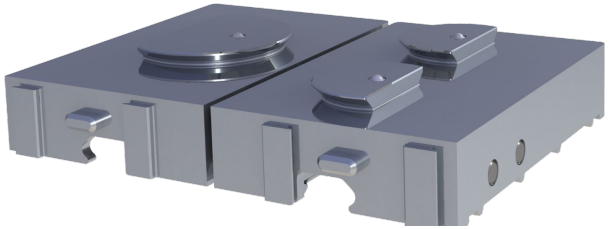
MultiGrip Jaws are available in OD (outside diameter) and ID (inside diameter) clamping.

The following page includes a summary of the MultiGrip Jaw offerings available, followed by principles for use.

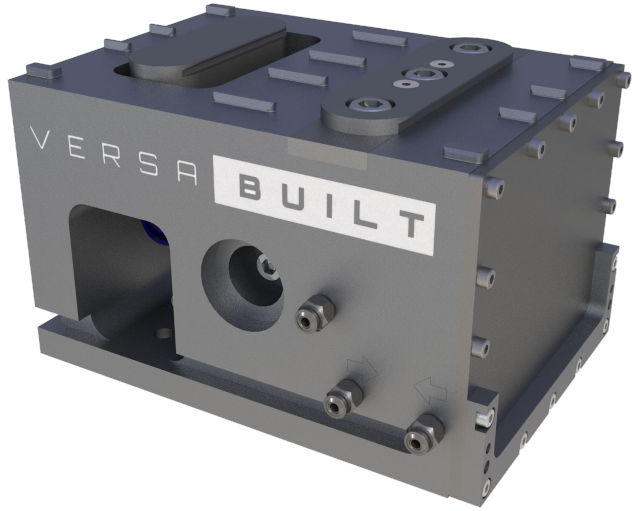
MultiGrip Top Jaws



MultiGrip Base Jaws



MultiGrip FJ Vise



MultiGrip Product Summary

MultiGrip FJ Vises

- MultiGrip FJ Vise (P/N 5008654) - Fixed Jaw Vise with 4240 lbs clamping force at 120 psi

MultiGrip OD Jaws

- MultiGrip Base Jaws, OD (P/N 5004027) - Base Jaws used with exchangeable Top Jaws
- MultiGrip Jaws, OD, 1.5” H (P/N 5004015) - OD Fixed Jaws, 1.5” height
- MultiGrip Jaws, OD, 2.5” H (P/N 5007653) - OD Fixed Jaws, 2.5” height
- MultiGrip Top Jaw Set, 1.0” H (P/N 5006796) - 1.0” Exchangeable Top Jaws for OD Base Jaws
- MultiGrip Top Jaw Set, 1.5” H (P/N 5002752) - 1.5” Exchangeable Top Jaws for OD Base Jaws
- MultiGrip Top Jaw Set, 2.0” H (P/N 5006795) - 2.0” Exchangeable Top Jaws for OD Base Jaws
- MultiGrip Top Jaw Set, Oversized, 1.5” H (P/N 5007394) - 1.5” Top Jaws 2” longer and 2” wider

MultiGrip ID Jaws

- MultiGrip Jaws, ID, 1.5” H (P/N 5007344) - ID Fixed Jaws, 1.5” height
- MultiGrip Jaws, ID, 2.5” H (P/N 5005782) - ID Fixed Jaws, 2.5” height
- MultiGrip Jaw ID Setup Fixture (P/N 5007434) - Fixture used when machining ID jaw pockets

MultiGrip Product Summary

Universal Jaw Products

- Universal Top Jaws (P/N 5007070) - Hard Anodized Top Jaw set mating with OD Base Jaws
- VersaBites, 3/16” (P/N 5009679) - Hardened Steel with 3/16” z-depth, mating with Universal Top Jaws
- VersaBites, 1/8” (P/N 5009847) - Hardened Steel with 1/8” z-depth, mating with Universal Top Jaws
- Machinable VersaRails (P/N 5009630) - 6061-T6 Aluminum workholding, mating with Universal Top Jaws

Standard MultiGrip Jaw Dimensions

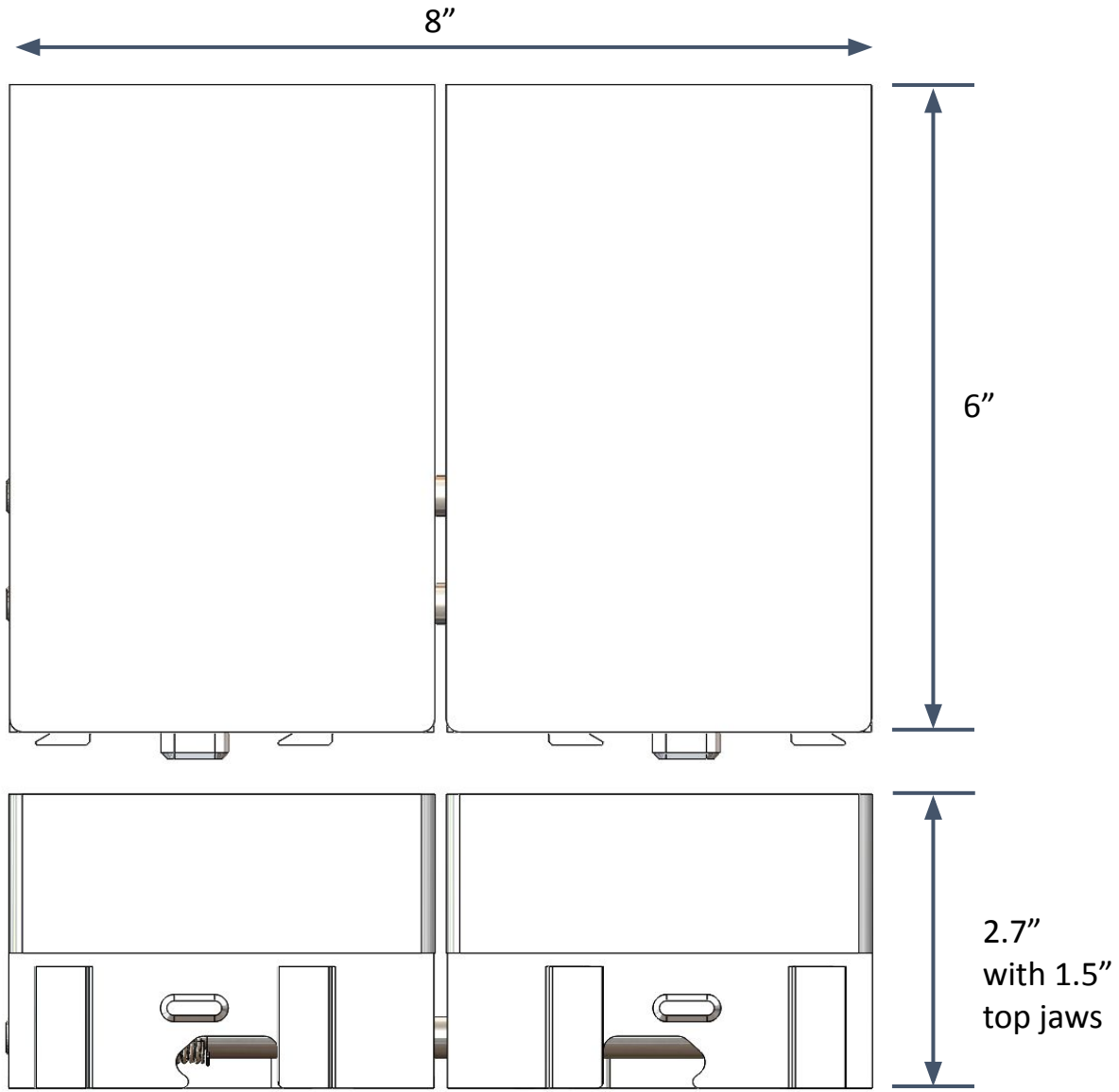
MultiGrip Jaws have a combined surface area of 6” x 8” with available z-depth that varies upon the selected jaw type (fixed jaws or base jaw with top jaws).

Top Jaws can be machined down with 0.375” remaining.

- 0.625” available pocket for 1.0” top jaws
- 1.125” available pocket for 1.5” top jaws
- 1.625” available pocket for 2.0” top jaws

Fixed Jaws can be machined down to 1.125” height

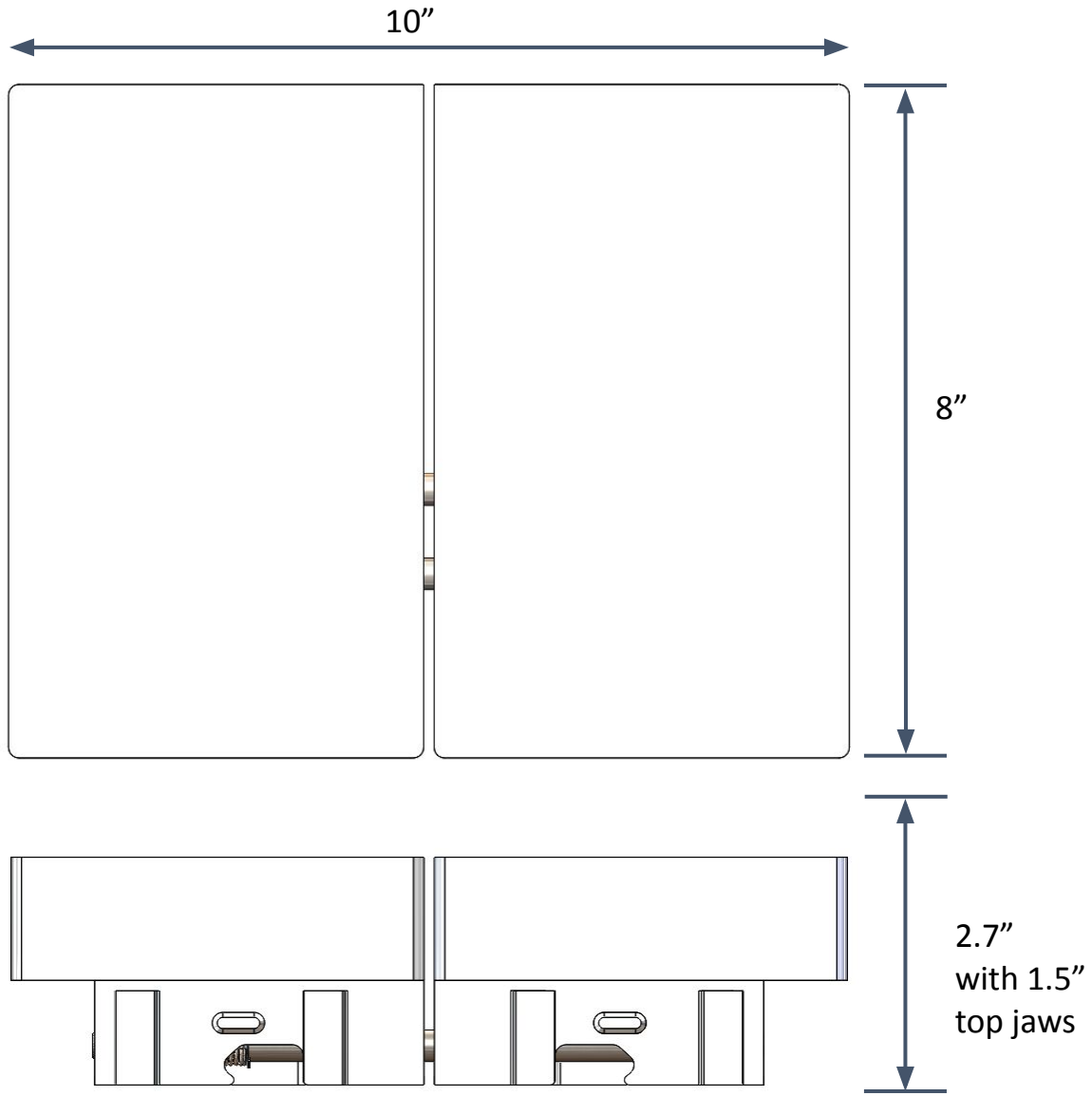
- 0.375” available pocket depth for 1.5” fixed jaws
- 1.375” available pocket depth for 2.5” fixed jaws



Oversized MultiGrip Jaw Dimensions

Oversized Top Jaws are available with dimensions shown on the right, giving 8 x 10” of machinable area.

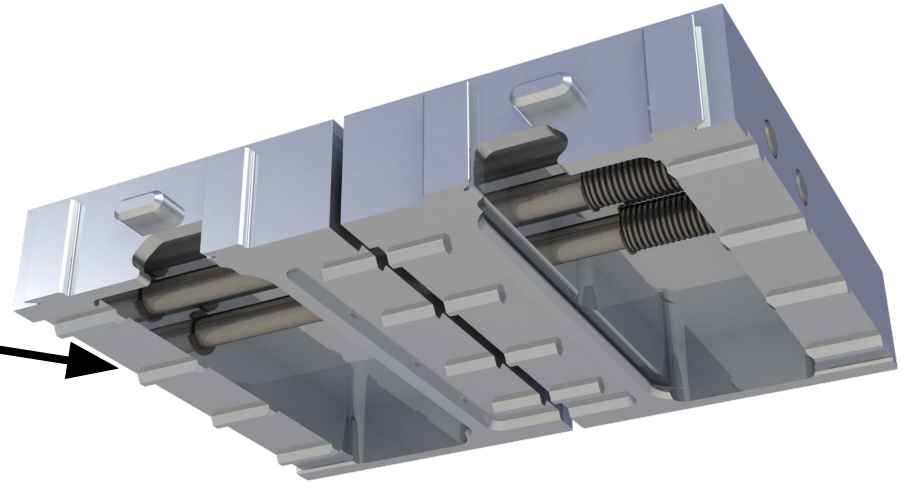
Note: custom jaw sizes or interfaces can be bolted onto fixed jaws or top jaws for geometries outside of those shown in this manual. For example: hardened steel or 3D printed interfaces can be fastened to jaws.

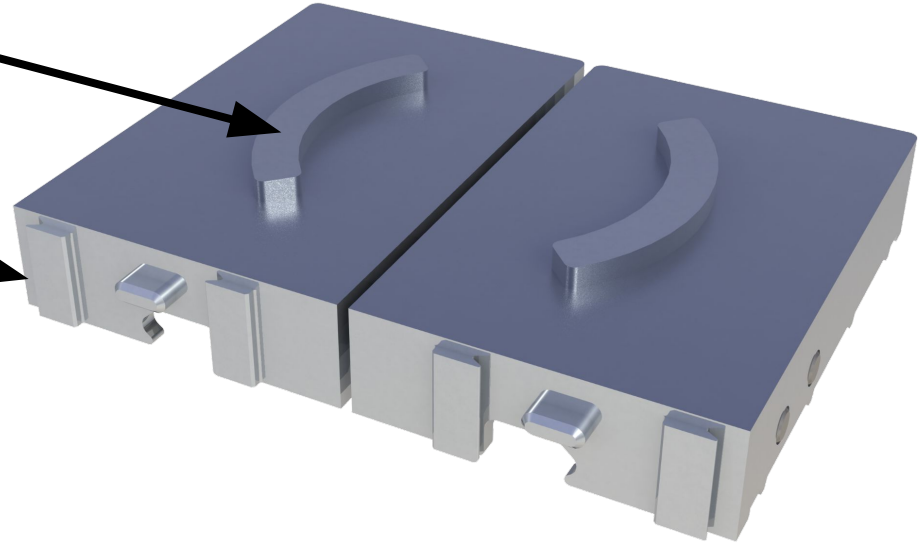


MultiGrip Jaw Details

Three interfaces to MultiGrip Jaws:

- MultiGrip Vise Interface
- Machinable Part Interface
- Gripper Interface

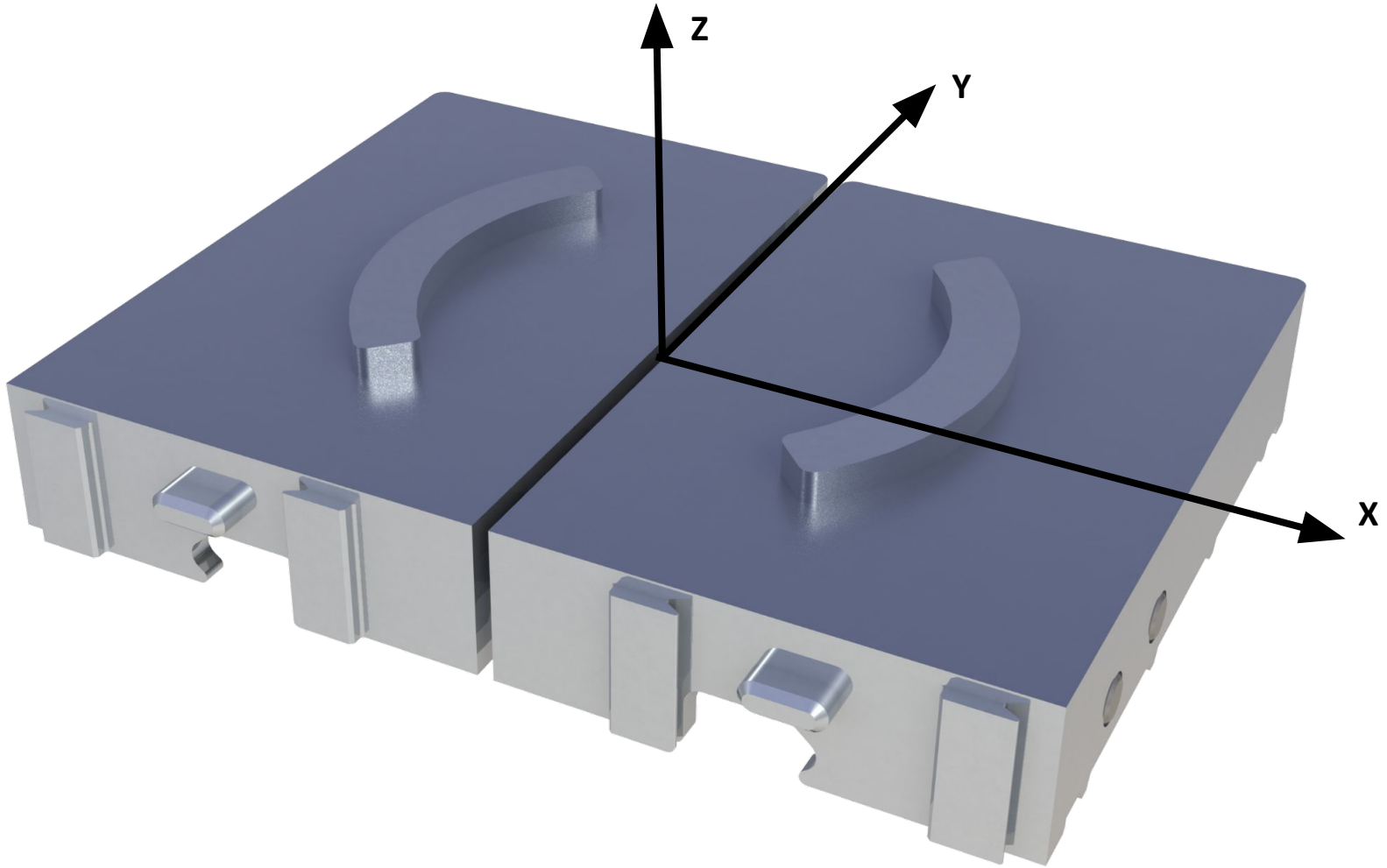




Solid Models are available at www.versabuilt.com or by contacting VersaBuilt via sales@versabuilt.com

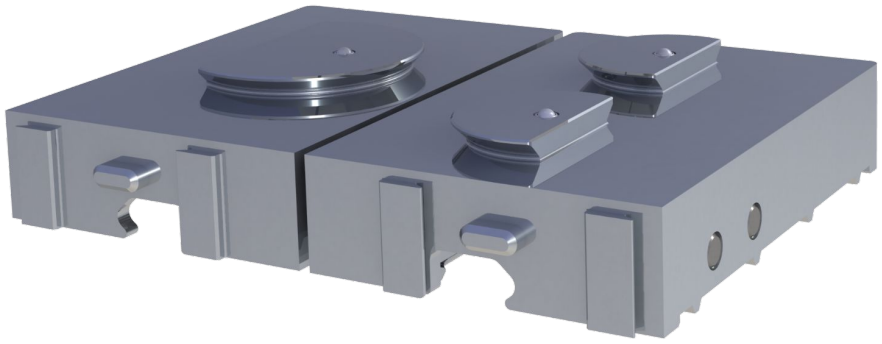
MultiGrip Axis Nomenclature

XYZ axis aligned with typical CNC axis



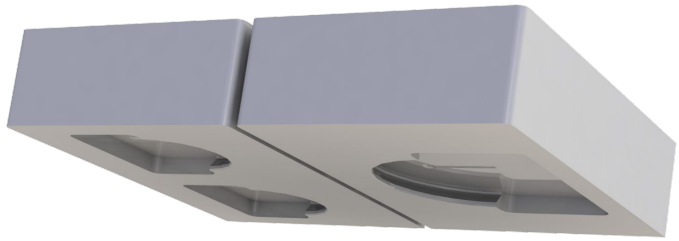
MultiGrip Jaw Types

MultiGrip Base Jaws



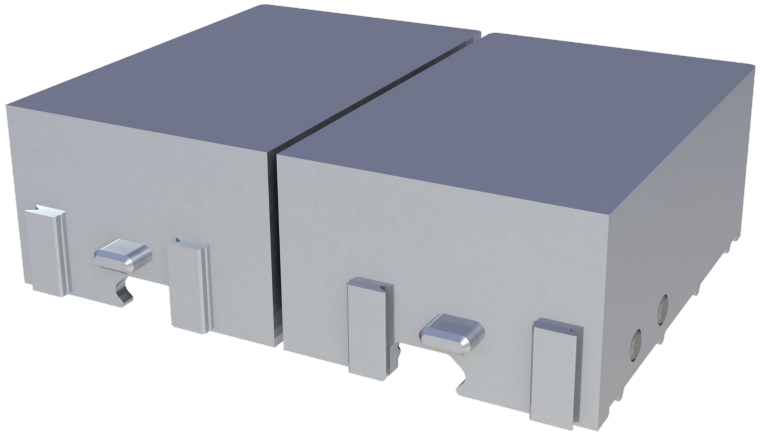
6061-T6 Base Jaws with robot and vise interface, plus Top Jaw interface for quick exchange of Top Jaws (available for OD clamping)

MultiGrip Top Jaws



6061-T6 Top Jaws available in multiple thicknesses (1.0, 1.5, 2.5 & 3.0”) for machining custom part interface (jaw pockets). Used with MultiGrip Base Jaws.

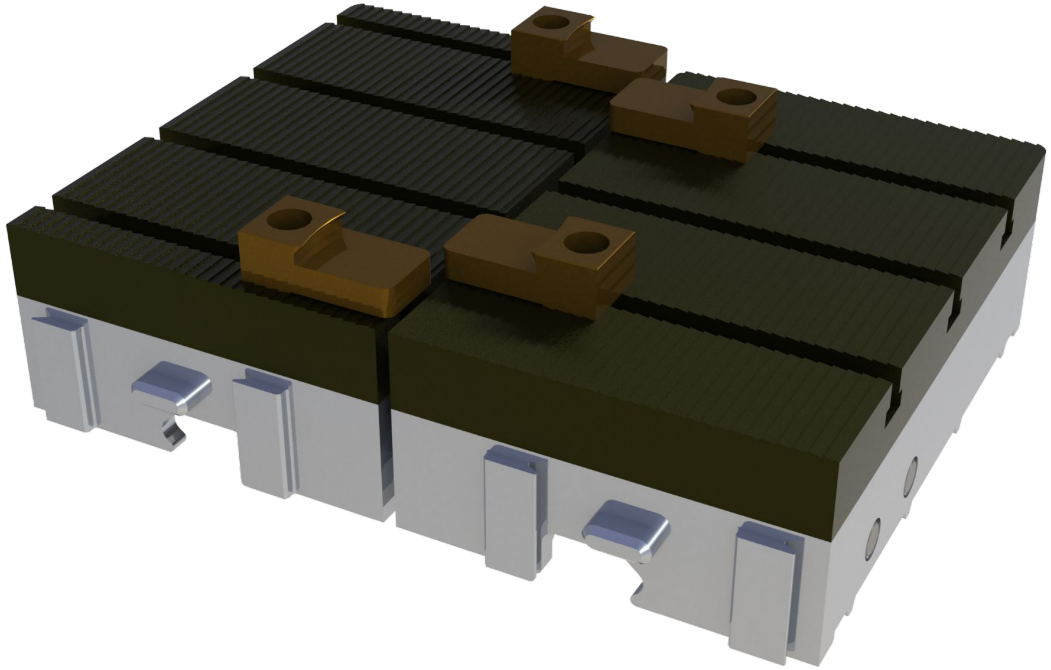
MultiGrip Fixed Jaws



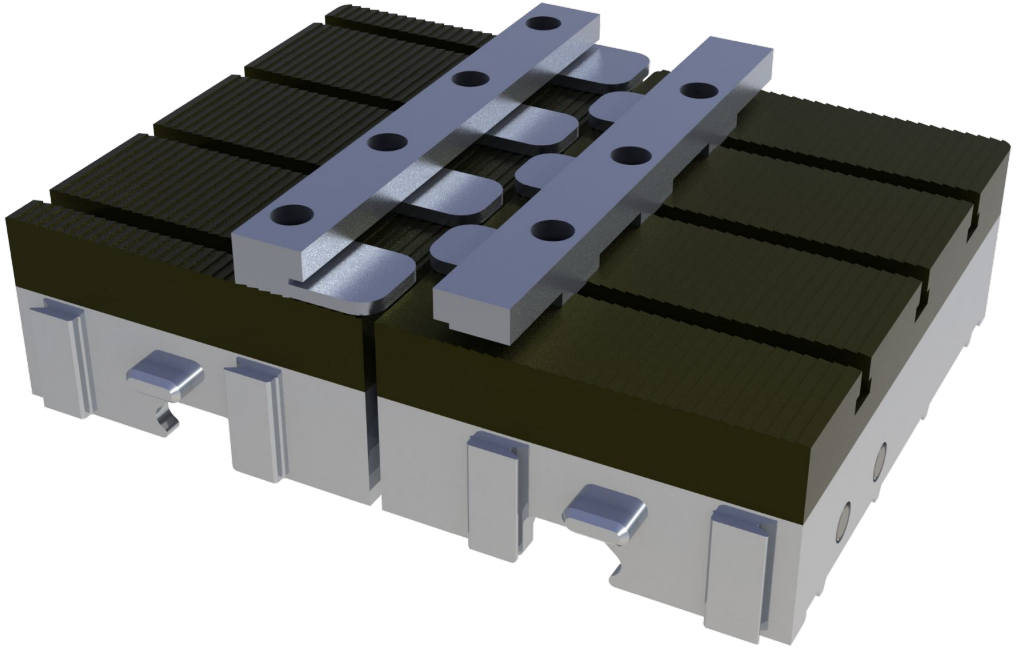
6061-T6 Jaws with robot and vise interface, plus material for machining custom part interface (jaw pockets). Available in for OD and ID Clamping in 1.5” and 2.5” heights.

MultiGrip Jaw Types

MultiGrip Base Jaws & Universal Top Jaws w/ VersaBites



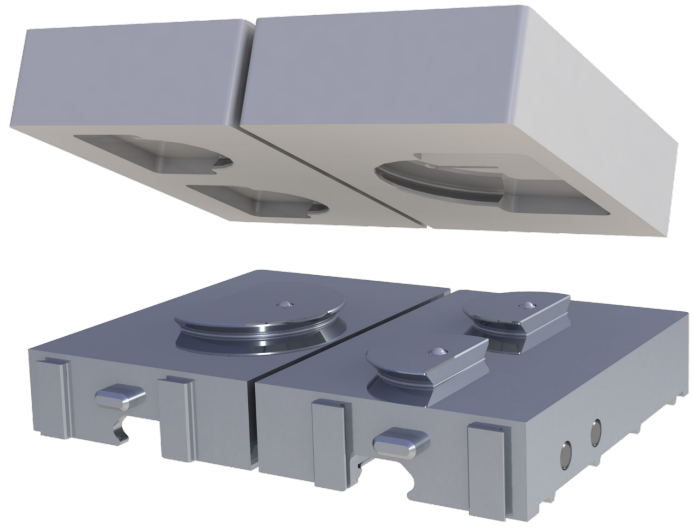
MultiGrip Base Jaws & Universal Top Jaws w/ VersaRails



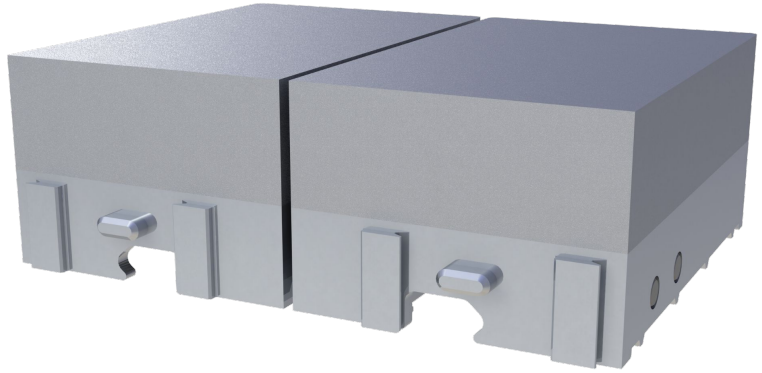
Refer to Universal Jaw Products Manual for more information

MultiGrip Top Jaws

- Part pocket machined into low-cost exchangeable Top Jaws
- MultiGrip Top Jaws snap into place on MultiGrip Base Jaws
- One fixed Top Jaw, one swivel Top Jaw
- Swivel Top Jaw allows jaws to conform to part, increases gripping force on part
- Slightly heavier and slightly taller than MultiGrip Fixed Jaws
- Top Jaws are available in standard and over-sized versions, with thickness of 1.0”, 1.5” and 2.0”



MultiGrip Top Jaws and Base Jaws Exploded

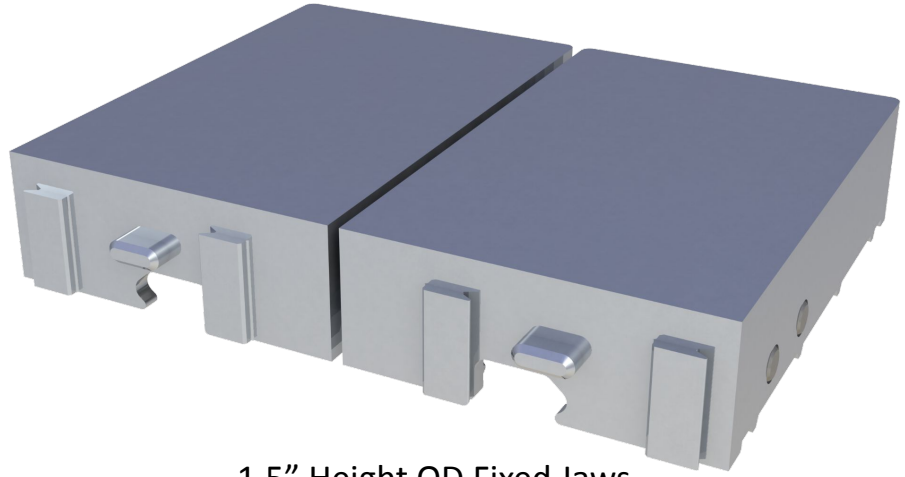


MultiGrip Top Jaws Mounted on MultiGrip Base Jaws

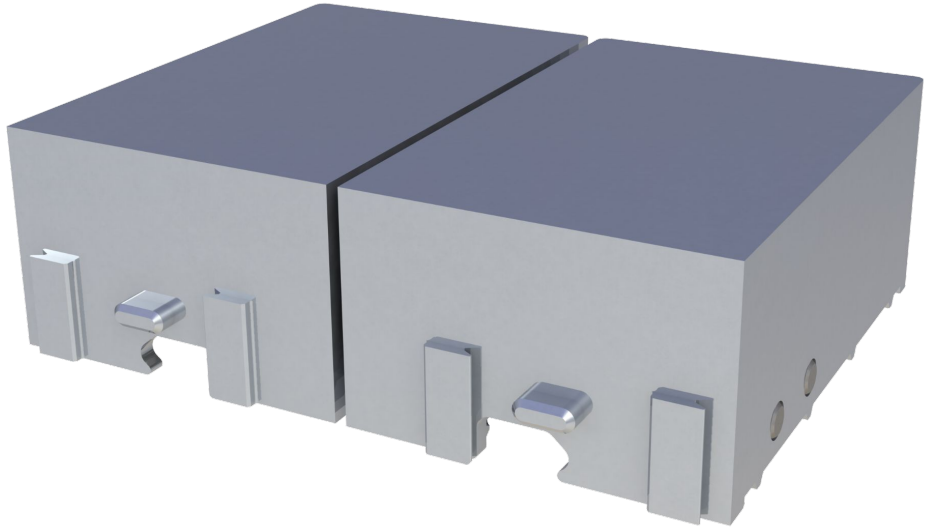
Top Jaws are available for OD Jaws only.
ID Jaws applications use Fixed Jaw.

MultiGrip Fixed Jaws

- Solid top surface to machine part pocket
- Typically single part use
- Used when low overall jaw height or lowest jaw weight is required
- Minimum overall height of 1.125”
- Available in **ID and OD** clamping styles
- Available in 1.5” and 2.0” heights
- Considerations must be made to accomodate jaw deflection during gripper pick of rectangular parts (See section Designing MultiGrip Jaws for Picking and Placing for more information)



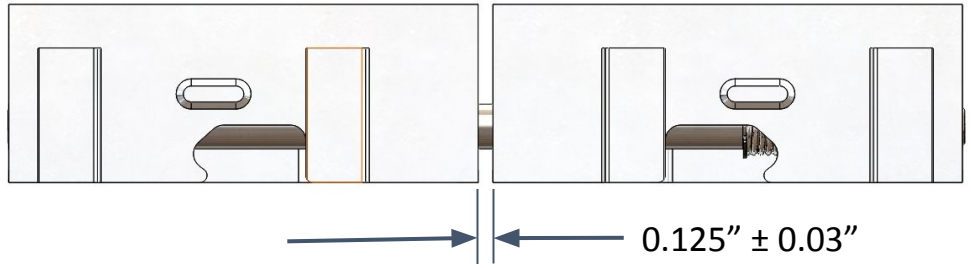
1.5” Height OD Fixed Jaws



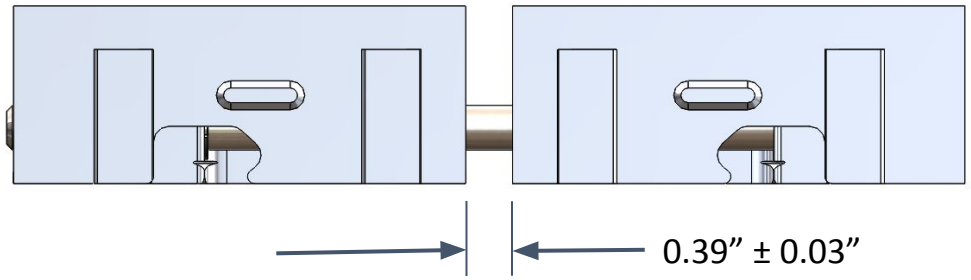
2.5” Height OD Fixed Jaws

MultiGrip Jaw Setup

- Left and Right Jaws need to include a gap to allow for raw material variations and allow open and close operations for robot processing
- The images to the right show the nominal gaps required



OD Jaws with 0.125” Nominal Gap
Machine Pocket with ⅛” spacer



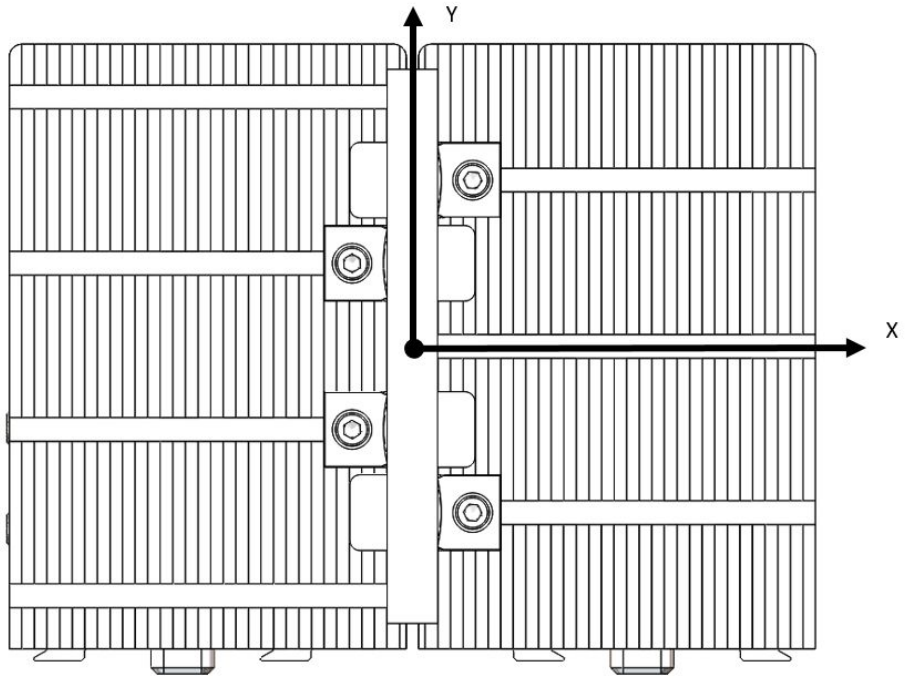
ID Jaws with 0.39” Nominal Gap
Machine Pocket with ID Jaw Fixture

MultiGrip Jaw Repeatability

- Best repeatability of the MultiGrip workholding system is achieved when MultiGrip Top Jaws are paired with the MultiGrip Base Jaws and the MultiGrip Vise they were originally machined on
  - A good practice is to dedicate at least one set of MultiGrip Base Jaws to each vise
  - Engrave an identifier on each Base Jaw that encodes the CNC machine and vise the Base Jaw is dedicated to
  - When machining Top Jaws, engrave both a part number for the Top Jaws and the identifying number of the Base Jaw it was machined on to make it easy for operators to match the correct Top Jaw and Base Jaw together
- Variability of the position of the MultiGrip jaws between clamping cycles occurs primarily along the X axis
  - The position of the fixed jaw (right jaw) will vary a small amount based upon the clamping pressure applied and the friction between the MultiGrip Jaws and MultiGrip Vise

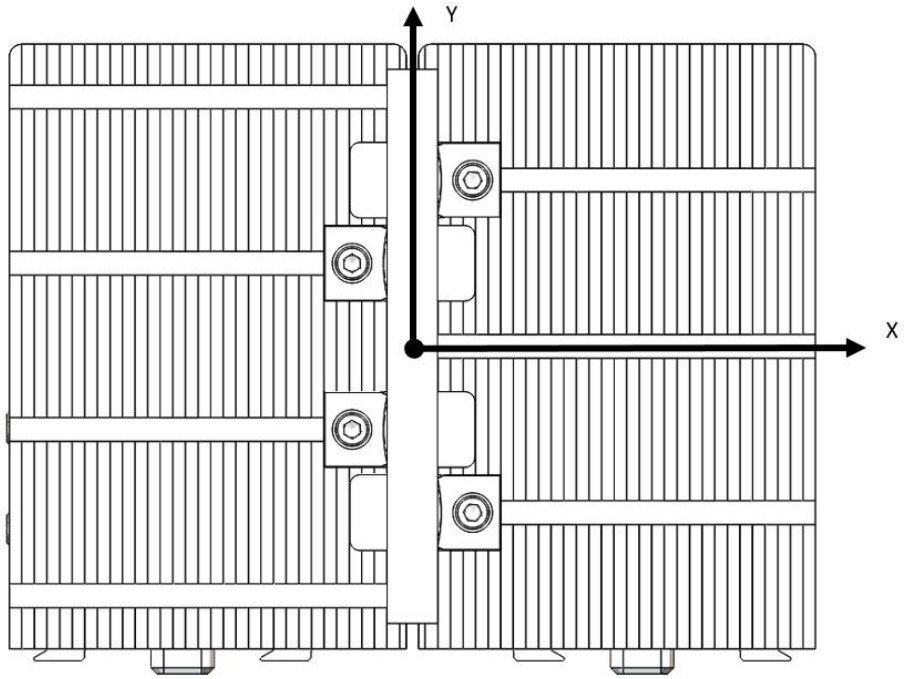
Best Practices: Setting the Machining Coordinate System

- When machining raw stock in the first operation, the requirements of the absolute position of the machined part relative to the raw stock are typically low
  - In this case, it is generally safe to use assumed center position of the vise found from the calibration plate in the installation process
- When machining the second operation or any operation in which critical dimensions must be maintained between how the part is held in the jaws and how it is finished
  - In this case best practice is to set the Machining Coordinate system by indicating the fixed (right) MultiGrip Jaw



Best Practices: Using Fixtures That Bite into Raw Material

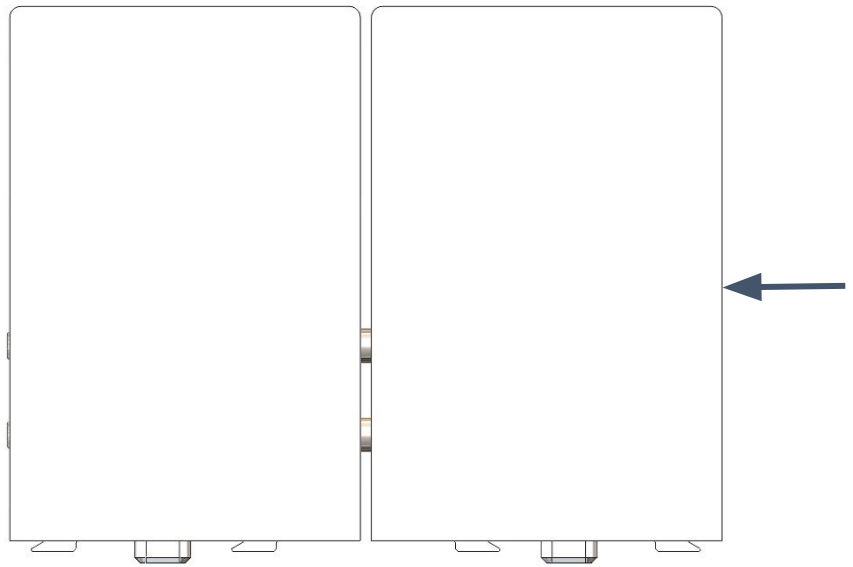
- When clamping raw stock using VersaBites, the part will shift to the right a small amount when clamped
- If the part boundaries are close to the width of the part, it may be necessary to offset the coordinate system to the right to compensate
- VersaBuilt recommends using a probe to center the work coordinate system in X when part boundaries are close to raw material boundaries
- To measure the shift of the part without a probe, place the raw material in the jaws and push the part to the right against the VersaBites; measure the distance from the right side of the part to the edge of the right jaw
- Clamp the part with the vise and measure the difference in distance



Best Practices: Indicating MultiGrip Jaws

Indicating MultiGrip Jaws in preparation for cutting new MultiGrip soft jaws:

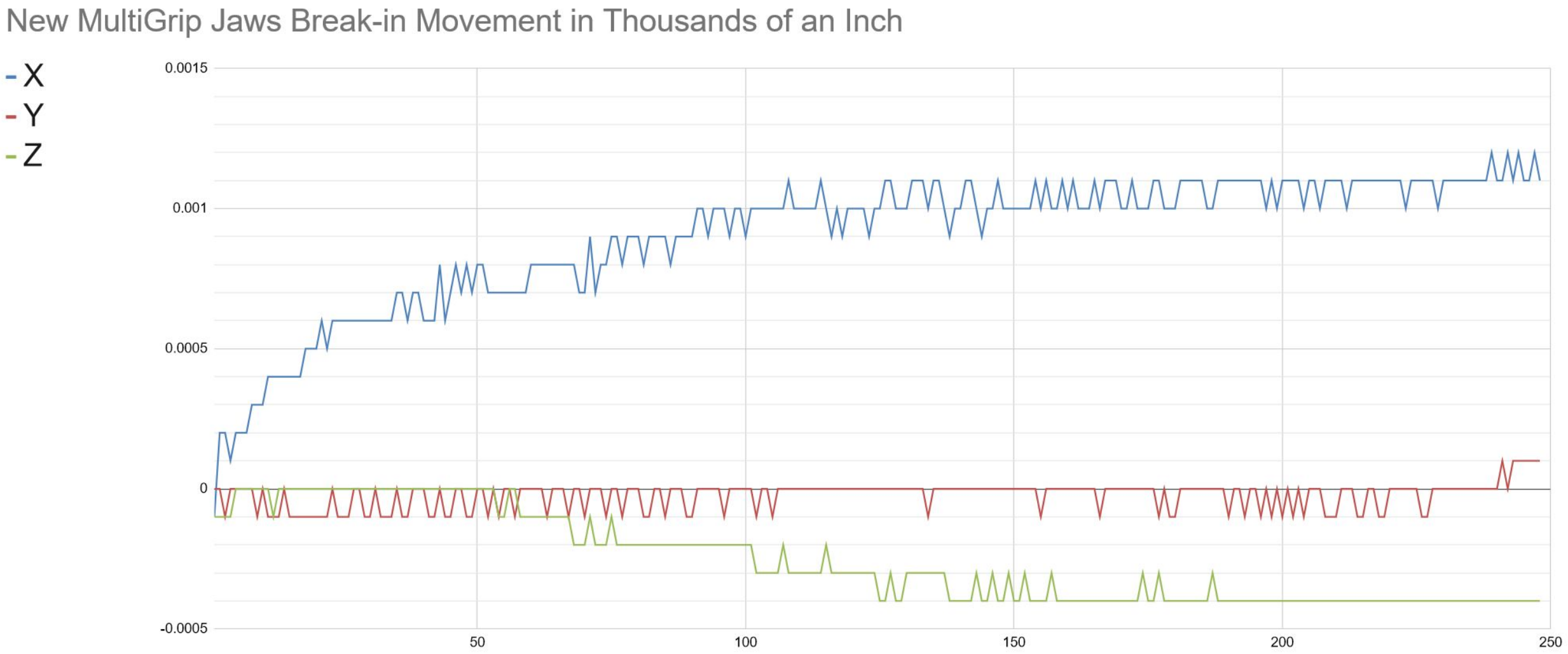
- Start with the vise home position found during vise setup and installation (see installation manual)
- Set the the vise air pressure to the clamping pressure that will be used during the machining process
- Turn on CNC coolant so the MultiGrip vise is covered in coolant
- Place the jaws on the MultiGrip vise and clamp the vise with the 1/8” machineable spacer installed
- Indicate the X position of the Machining Coordinate System from the right Top Plate or MultiGrip Jaw as shown
- If you prefer to set the CAM coordinate system to the center of the jaws, shift the measured X value 4” to the left
- Generally, variability in Y is minimal and does not require a change from the vise home position



Best Practices: New MultiGrip Jaw Break-in

- New MultiGrip Fixed Jaws or MultiGrip Base Jaws have a break-in period
- During the break-in period the position of the jaws after each clamping cycle will move more than after the break-in period
- After the break-in period, MultiGrip Jaws will generally repeat to position within 0.0005” between clamping cycles
- Most of the break-in movement takes place in the first 100 open/close cycles when the jaws will move primarily in X
- Jaws can be broken in by hand by first soaking the vise with coolant and then clamping empty jaws in the vise, using a dead blow to move the right jaw off the dovetail after each open
- Alternatively, indicate the position of the jaws with a spindle probe before each machining cycle
- See next page for chart details

Best Practices: New MultiGrip Jaw Break-in



Dry Machining with MultiGrip

- MultiGrip relies on CNC coolant to lubricate the vise interface, the gripper interface and the jaws
- If possible, run a vise wash program with coolant after the dry machining is completed to wash away chips and lubricate the vise, gripper and jaws
- If no coolant is available, use of a dry lubricant is required to be applied at least daily to the vise interface, gripper interface of the jaws, cross-pins of the jaws, and the face of the gripper

MultiGrip Jaw Design and Machining

Section 4

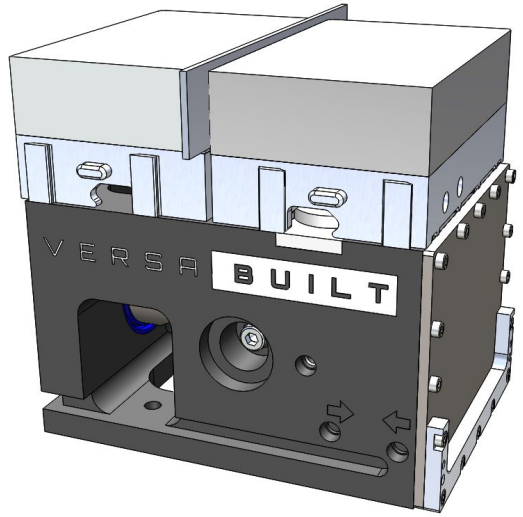
MultiGrip Jaw Design and Machining

Designing and cutting MultiGrip Jaws should follow the same best practices used with any other vise soft jaw and the guidelines in this section.

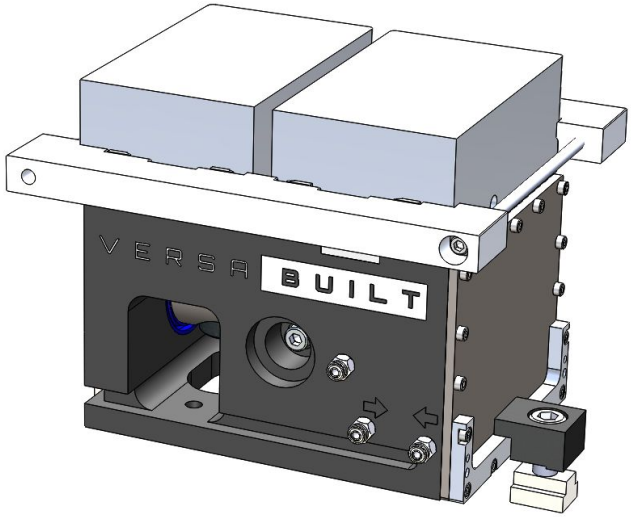
Design MultiGrip Jaws that will be rigid enough for the intended machining operations and capable of reliably picking, transfering or placing parts.

Cutting MultiGrip Jaws

- Before cutting MultiGrip jaws, with fresh coolant on the vise, load the empty jaws into vise and cycle the jaws open and closed several times
- For OD Jaws, position the included 0.125” wide machinable jaw spacer in the jaws so that the bottom of the jaw spacer is between 0.125” and 0.250” below the lowest part of the jaw pocket to be cut.
- For ID Jaws, position the ID Jaw Fixture around the lower section of the jaw (near the top of the Gripper interface features), then open vise against the Fixture stops to set the jaw gap.
- Before machining the jaw pocket, set the vise clamping pressure to the intended clamping pressure during automated processing or the maximum clamping pressure of the vise



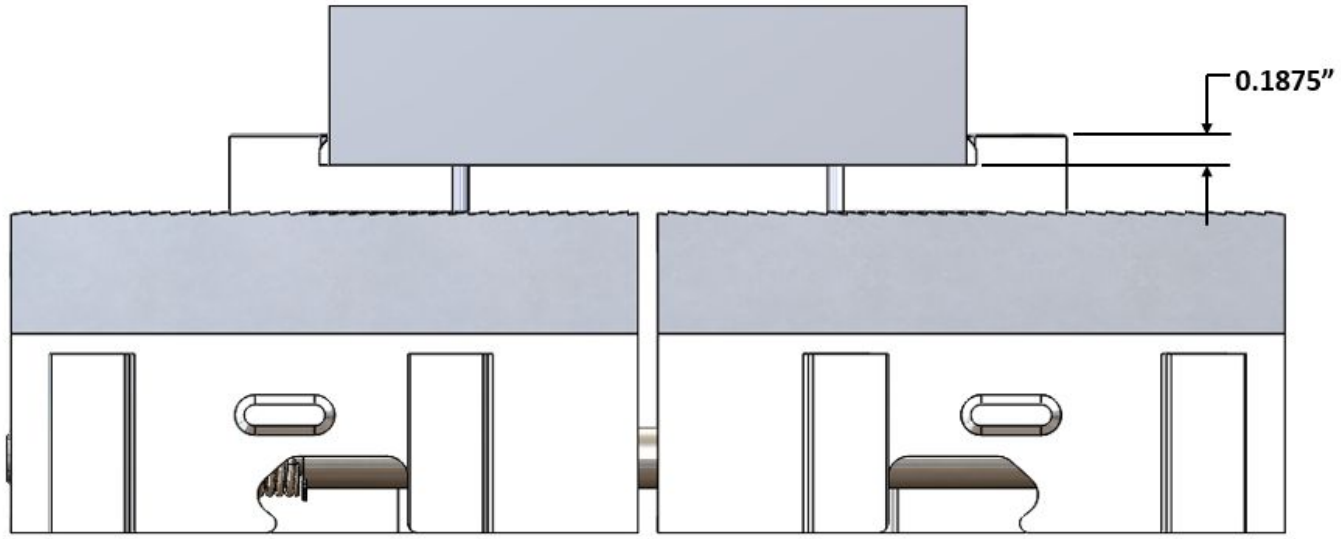
OD Jaws with 1/8” spacer



ID Jaws with ID Jaw Fixture

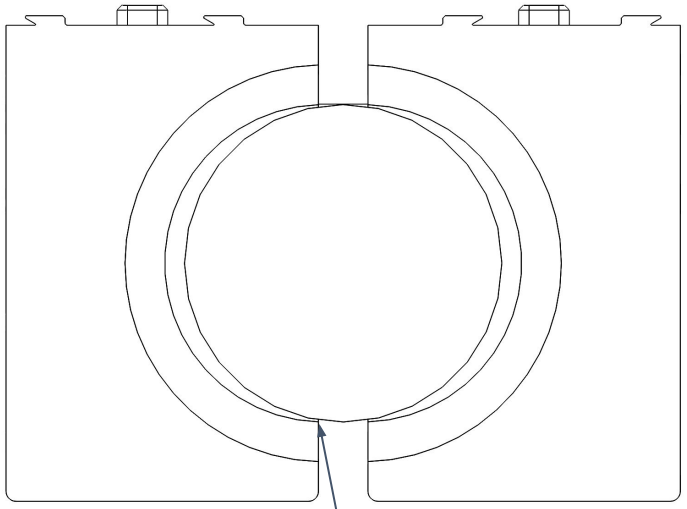
Jaw Pocket Depth

- For OP1 jaws that will pick the part from infeed, we recommend a minimum pocket depth of 0.1875” (4.75mm)
- An accurate robot with a well calibrated table can be successful with a pocket of 0.125” (3mm)
- For OP2 jaws that will be used to transfer the part from OP1, we recommend a minimum pocket depth of 0.100” (2.5mm)

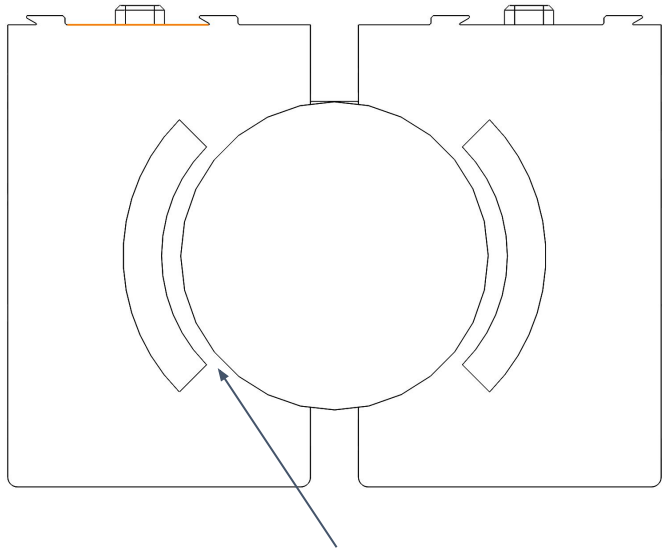


Clearance Between Jaw Pocket and Part During Pick

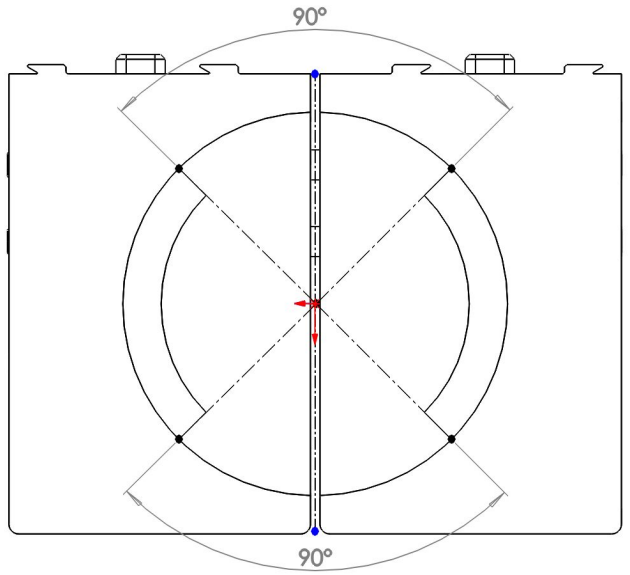
- Design the part pocket so that when the jaws are fully open, there is adequate clearance between the the part and pocket
- Avoid pocket features that approach parallelism with the X plane of the jaws
- For round parts we recommend a 90 degree clearance cut along both sides of Y axis



Not enough clearance between part and jaws during pick



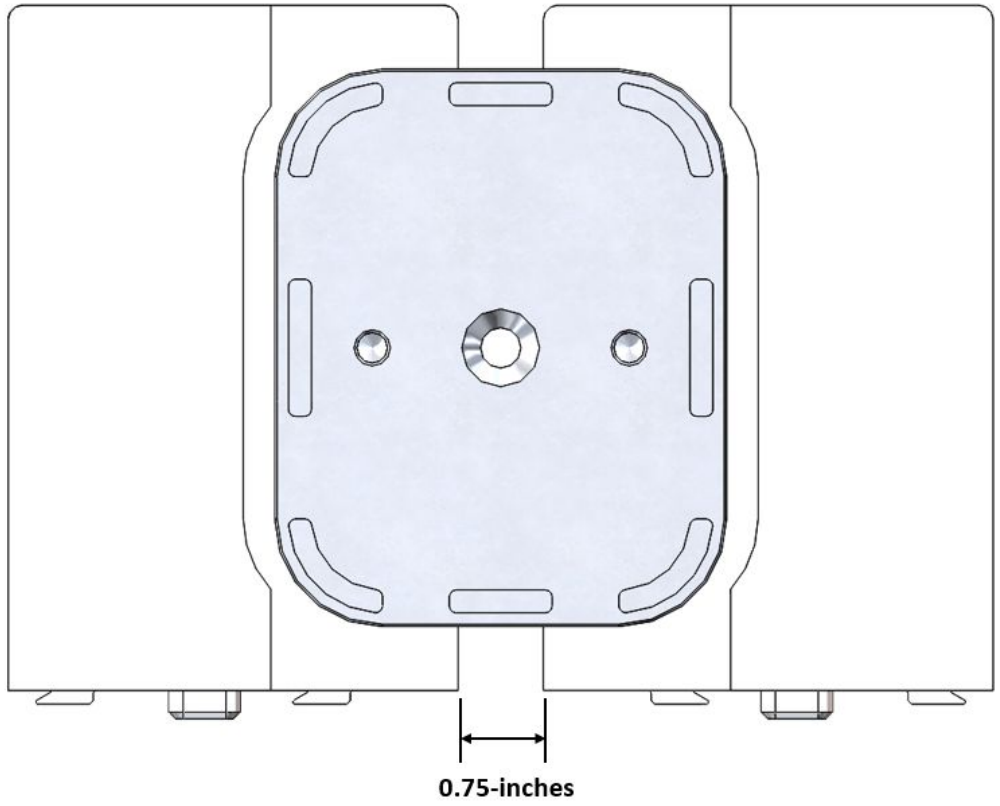
Enough clearance between part and jaws during pick

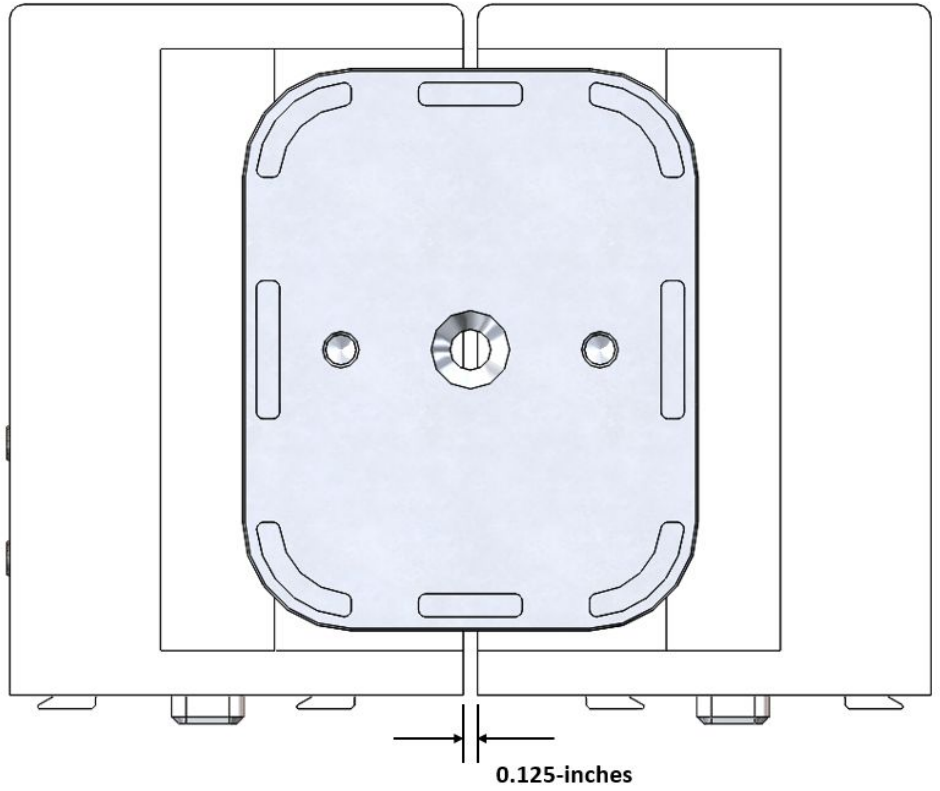


90 degree cut along Y axis for part clearance

Clearance Between Jaw Pocket and Part During Pick & Place

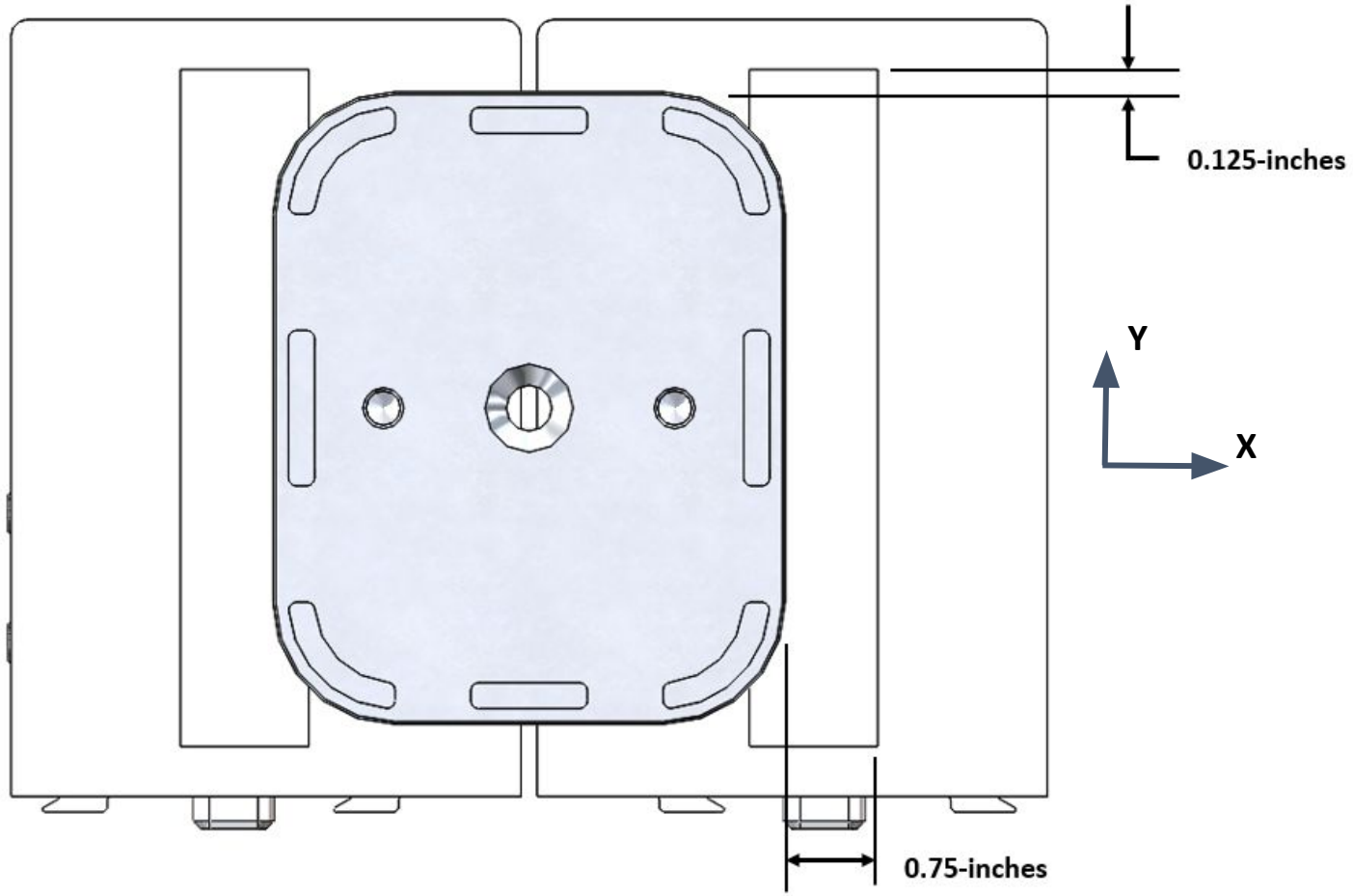
- Consider the jaw stroke and nominal clamp positions during pick
- OD jaws max opening = 0.75” (~20mm), nominal vise clamp = 0.125”
- ID jaws min closing = 0.0”, nominal clamp = 0.394” (10mm)





Clearance Between Jaw Pocket and Part During Pick & Place

- Maximum X-direction sidewall = 0.75-inches
- Maximum Y-direction sidewall = 0.125-inches



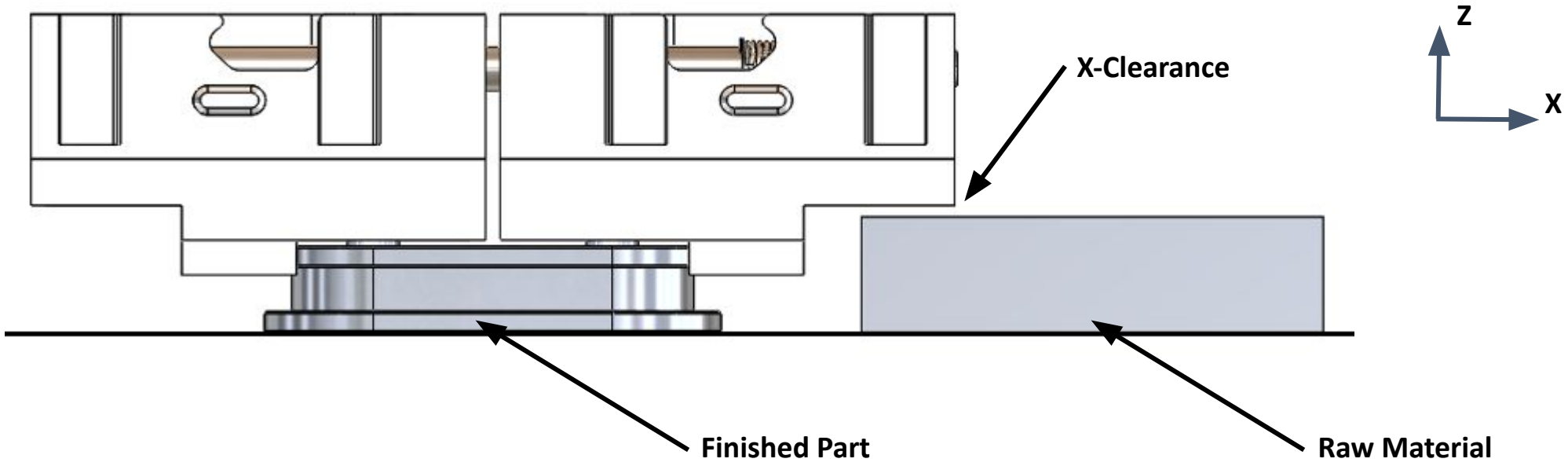
Default layout of parts on the VersaCart are arranged for maximum density, assuming the sidewall dimensions shown.

If you cannot design your jaws with minimized sidewalls, the layout of parts on the VersaCart will need to be changed to a lower density to clear the full jaw size.

Refer to the VSC Mill Operators Manual for information about custom part spacing.

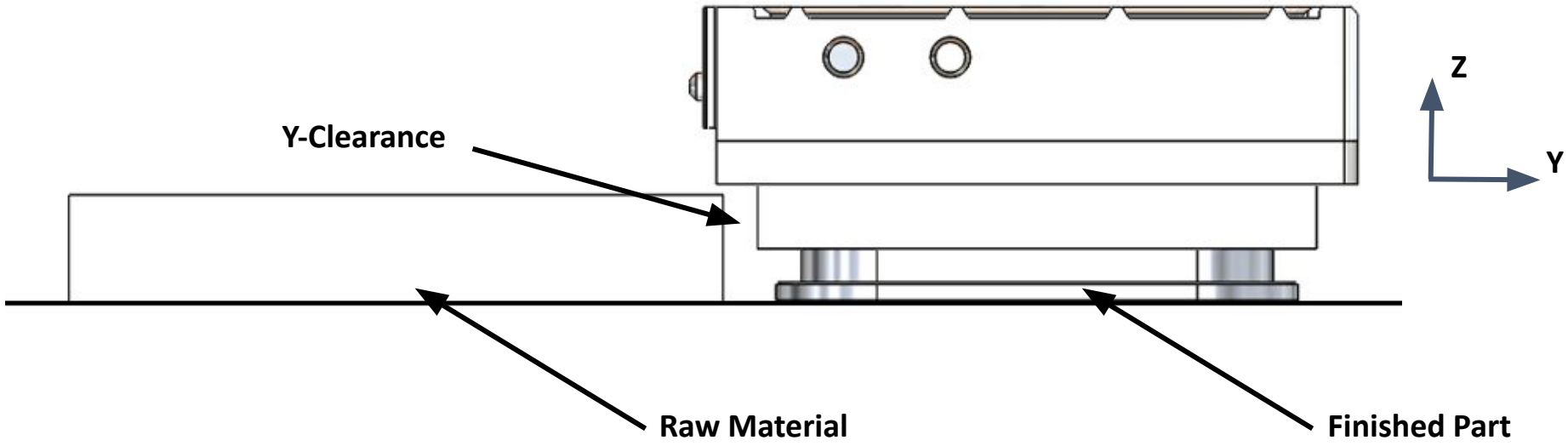
Clearance Between Jaw Pocket and Part During Pick & Place

- Include Z-clearance between the jaw and adjacent parts on the VersaCart during picking of raw material and place of finished parts
- Clearance needs to be in X and Y Directions
- The image below shows placing a finished part on the VersaCart, with X-Clearance to clear adjacent raw material



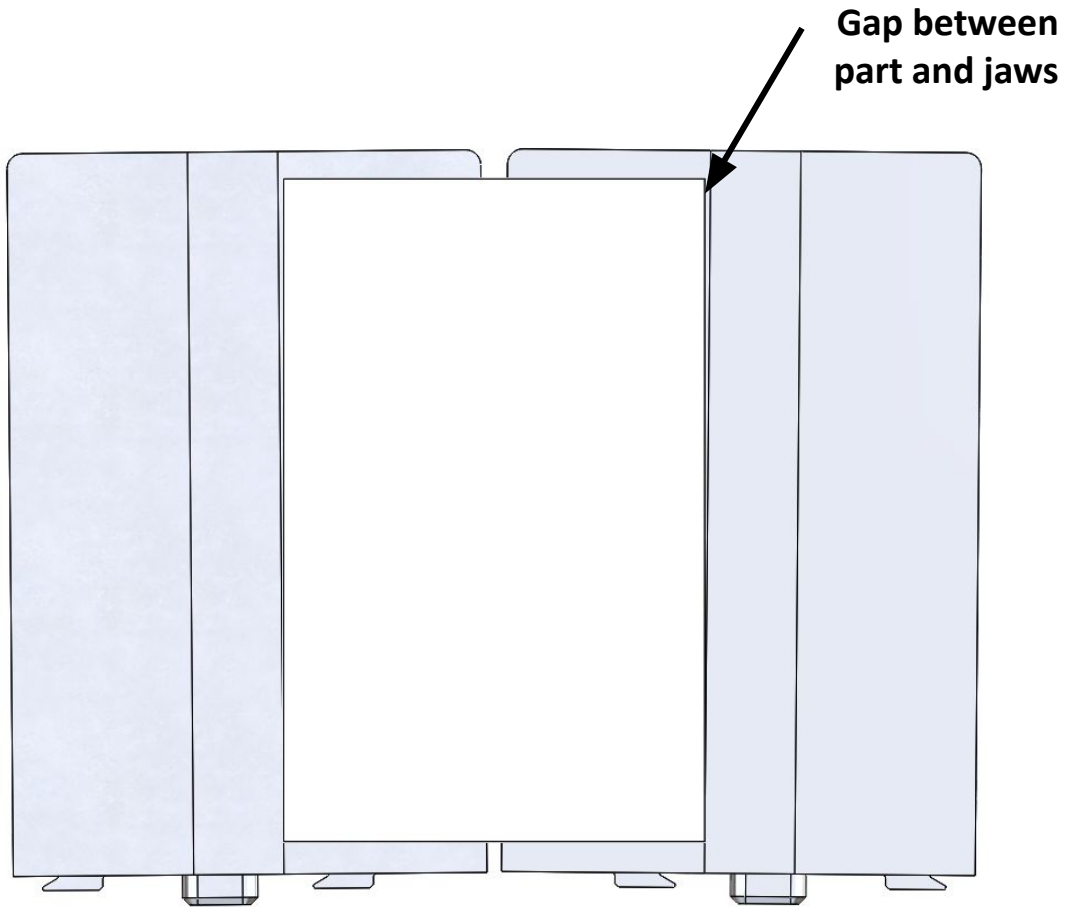
Clearance Between Jaw Pocket and Part During Pick & Place

The image below shows placing a finished part on the VersaCart, with Y-Clearance in the jaw pocket to clear adjacent raw material



MultiGrip Fixed Jaws Deflection During Pick

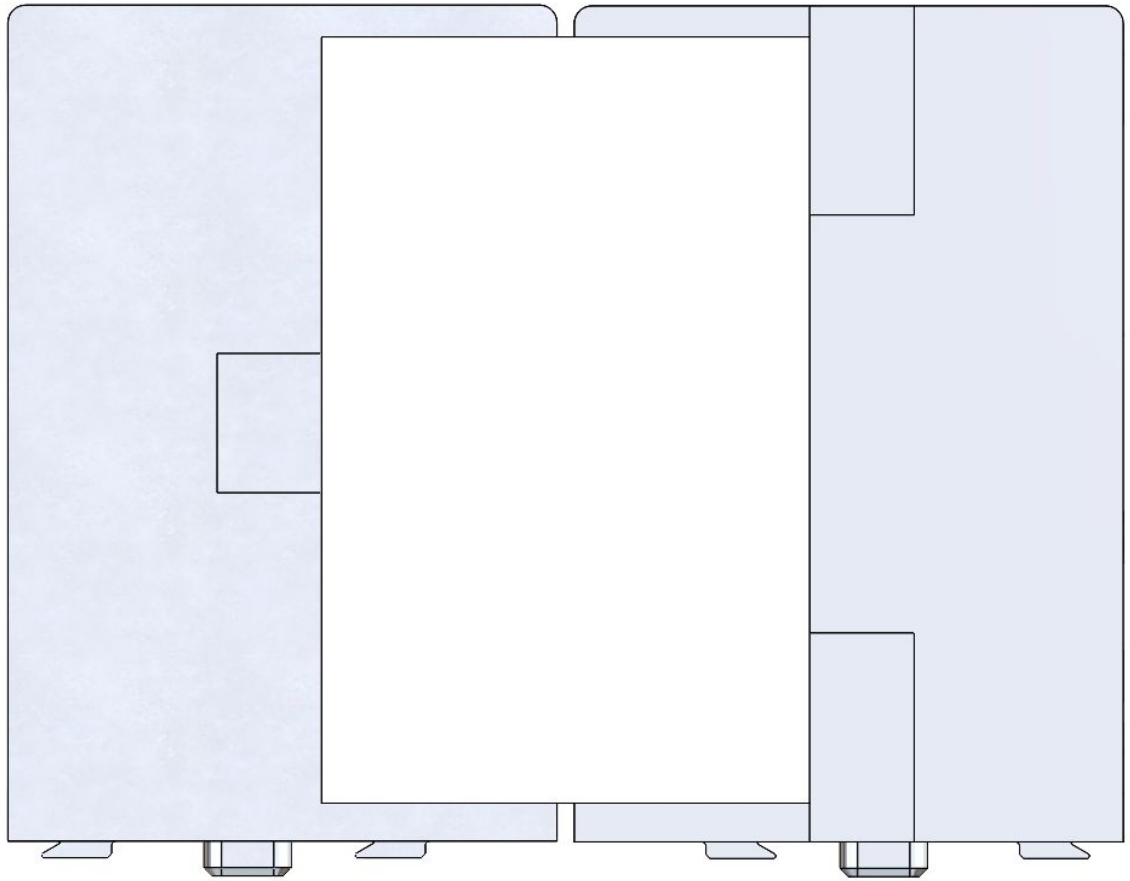
- MultiGrip ***Fixed Jaws*** will deflect a small amount during part grip* and with parallel wall jaws, the jaws with grip the front of the part producing poor picking results (see the following page for fixed jaw pocket design for rectangular parts)
- MultiGrip Top Jaws include a fixed jaw and a swivel jaw; the swivel jaw is designed to rotate to ensure full part contact with the part during part pick as the jaw deflects
- MultiGrip Fixed Jaws do not have a swivel jaw and will not be able to pick some part shapes without additional considerations



* This type of jaw deflection does not occur when MultiGrip Jaws are loaded into a MultiGrip Vise. MultiGrip Base Jaws with Top Jaws accommodate jaw deflection and generally no changes for jaw deflection are required.

MultiGrip Fixed Jaw Deflection During Pick

- When using MultiGrip Fixed Jaws with rectangular parts, triangulation of the jaw pocket will provide good results during pick, fully constraining the part against the 3 points of contact.
- Triangulation of the of the jaw pocket is not necessary for round parts using MultiGrip Fixed Jaws.

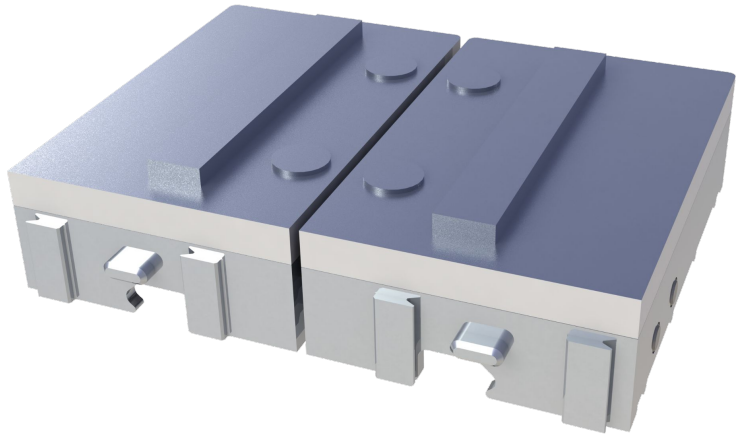


Part Settling

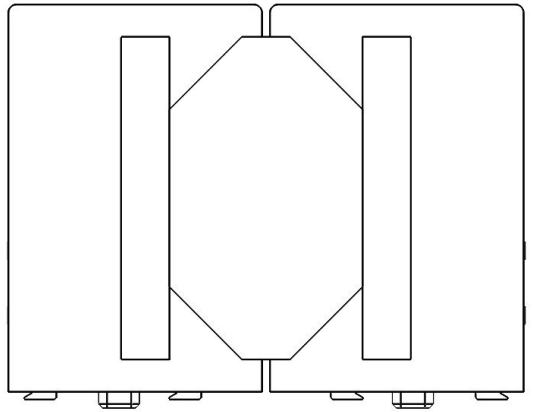
- Part settling is the term used to accurately position a part in the MultiGrip jaw pocket for CNC processing
- Accuracy and repeatability of the workpiece in the workholding can be affected by the part geometry, part weight and the jaw pocket design
- Almost any part can be accurately positioned in MultiGrip Jaws for automated processing using the right combination of tools for the part being settled:
  - Sound jaw pocket design
  - Opening and closing the vise after loading to settle part in Z
  - CNC settling programs and part settling tools
  - CNC spindle probes

Part Settling

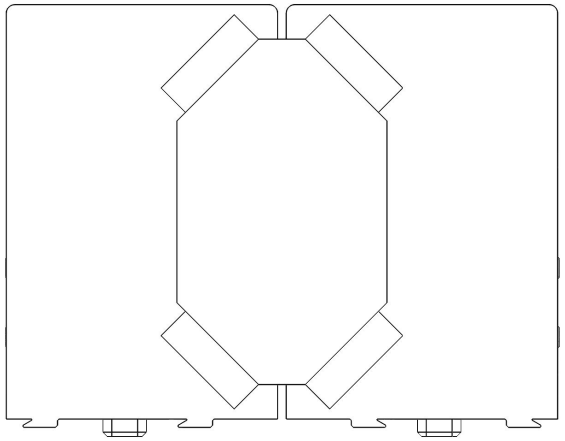
- To prevent part lift in Z during clamp, avoid a radiused corner between the Z locating surface of the jaws and the jaw pocket wall
  - Pads on the floor of the jaw pocket are a simple solution
- When possible, use the shape of the part to locate the part in Y and if required, rotation about Z



Pads on floor of Jaw Pocket



Jaw Pocket does not locate part in Y



Jaw Pocket locates part in Y and rotation about Z

Pick Settle and Vise Settle

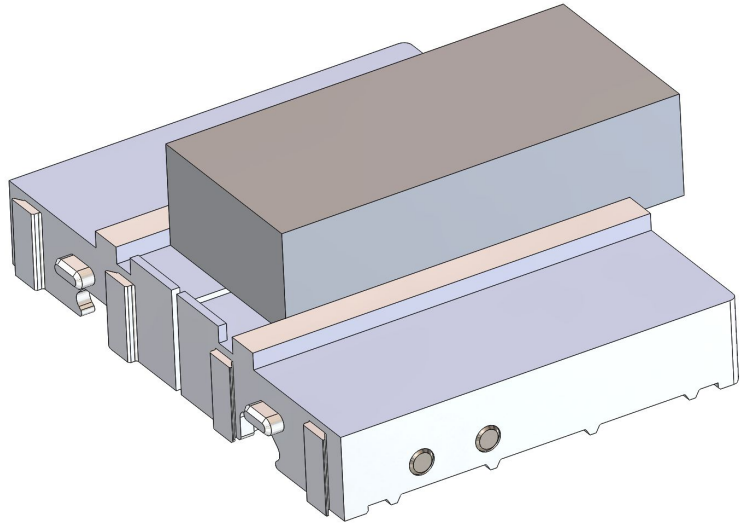
- After picking a part from infeed or the OP 1 vise, the part will not be settled fully in Z
- By default, the VersaBuilt System Controller (VSC) will open and close the gripper after the pick to make sure the part is held securely
  - Settling the part in the gripper does not ensure the part is full seated in Z after the jaws are loaded into the vise
- By default, the VSC will open and close the vise after load to ensure the part is settled in Z using the force of gravity
  - If gripper settle and vise settle options are not adequate, contact VersaBuilt support for additional settling options for your application

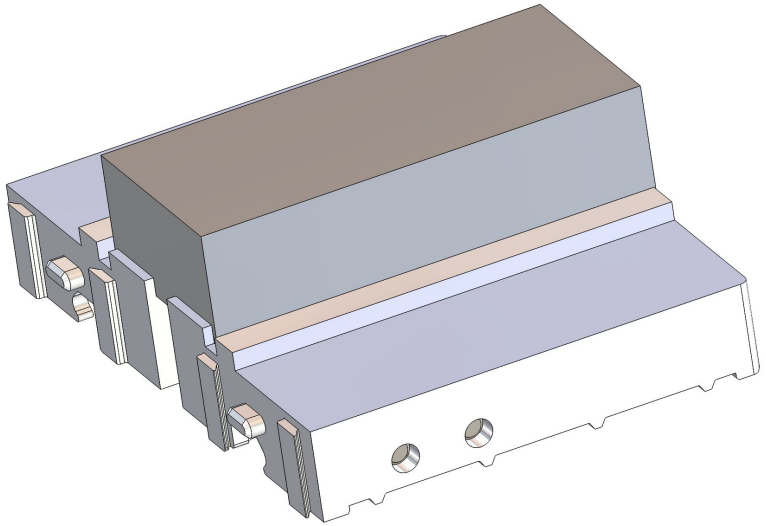
OP 1: Locating Rectangular Parts in Y

- Rectangular part shapes can shift along the Y axis when picked from infeed
- Operators typically cannot locate the part accurately enough to ensure the machining operation is successful
- There are two options for locating rectangular parts in Y:
  - Building a Y datum into the MultiGrip Jaws and using the Pick Settle option with a Pick Settle Angle
  - Using the OP 1 Y Push option to allow the robot to push the part to a datum after the vise is loaded
- OP 1 Y Push is generally accurate enough for first operations and works well with the Versabuilt Universal Top Jaws

OP 1 Pick Settle with Y Datum in MultiGrip Jaws

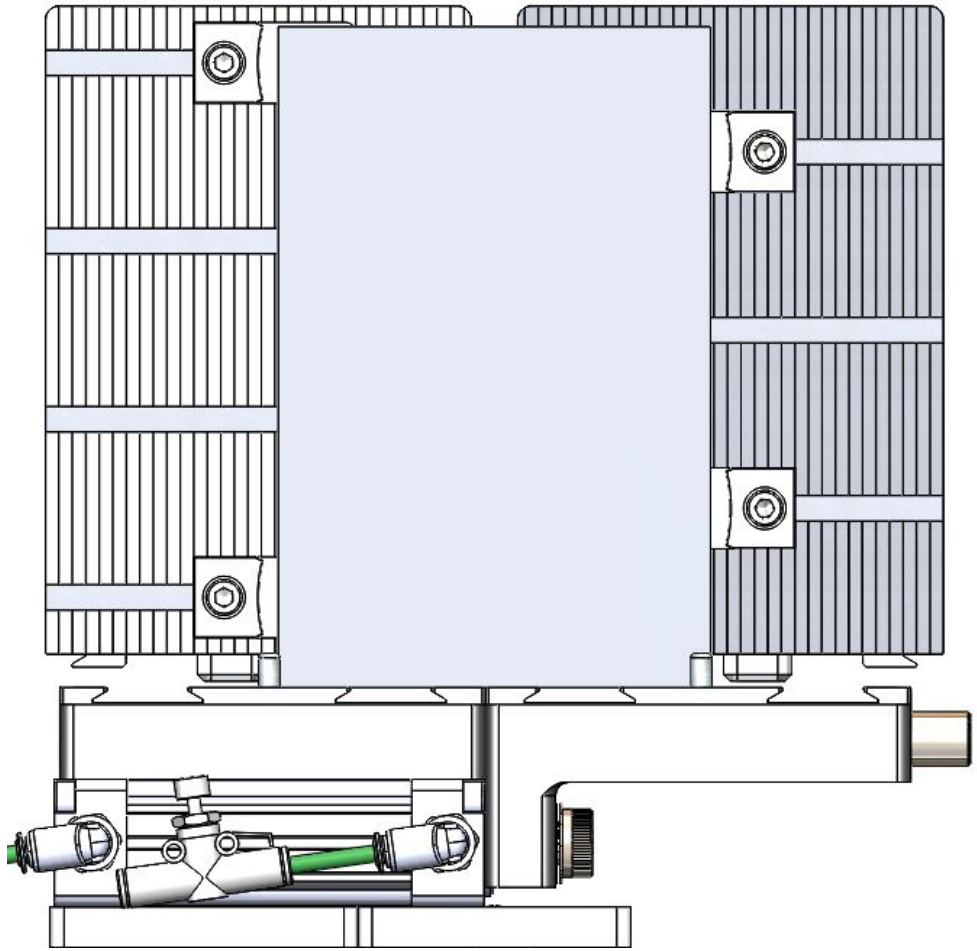
- To use Gripper Settle to locate a part in Y, the jaws should be designed with a datum in Y, generally near the negative Y edge of the jaws
- The datum should be positioned so the part is centered in the jaws if the part is less than 5.5” in length; for longer parts, the datum should be at the front edge of the jaws and the part will overhang the jaws in the positive Y direction
- In the Part Configuration, under Advanced Configuration, a Pick Settle Angle can be specified
- For a Y datum nearest the gripper interface, use a positive Pick Settle Angle



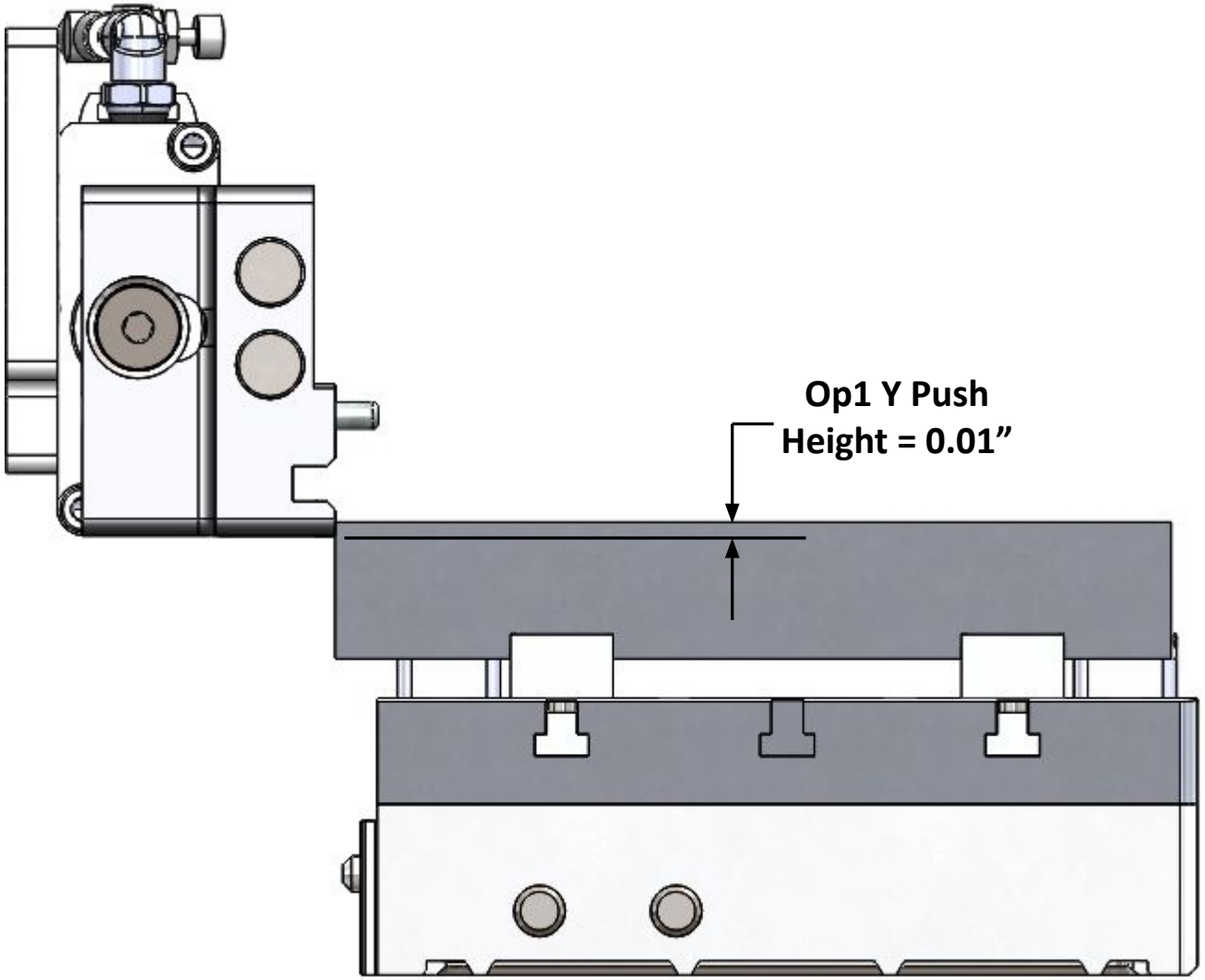


OP 1 Y Push

- OP 1 Y Push, using the robot gripper, can be used to push the part into position. Op 1 Y Push option is available when Show Advanced Configuration is selected in the Part Configuration
- By default, the robot will use the gripper to push the part to the center of the vise based upon the part length entered
- Optionally, the height offset the gripper pushes the part can be set
- The **OP 1 Y Push Height Offs** is an offset from the top of the part loaded in the vise the the gripper will push from
  - Default value is -0.150” (3.5mm) or 0.150” below the top of the part; positive values would be above the part
  - Top of the part is calculated from the **Pick Height**
- **OP 1 Y Push works best with parts wider than 2”; always test the OP 1 Y Push before assuming it will work for your application**



OP 1 Y Push

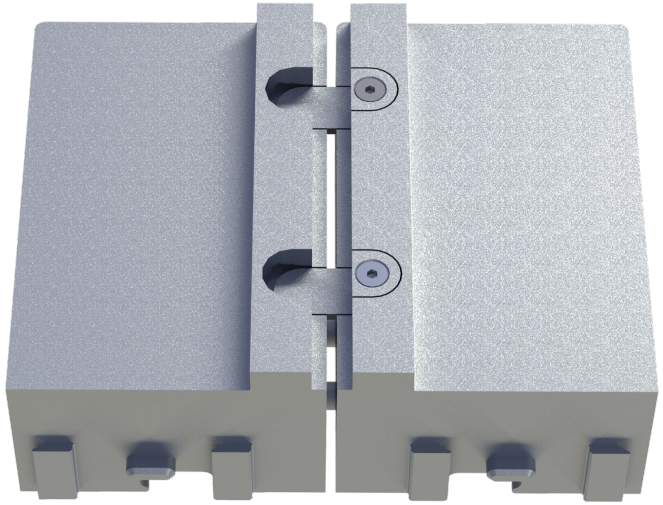


OP 2: Locating Rectangular Parts in Y

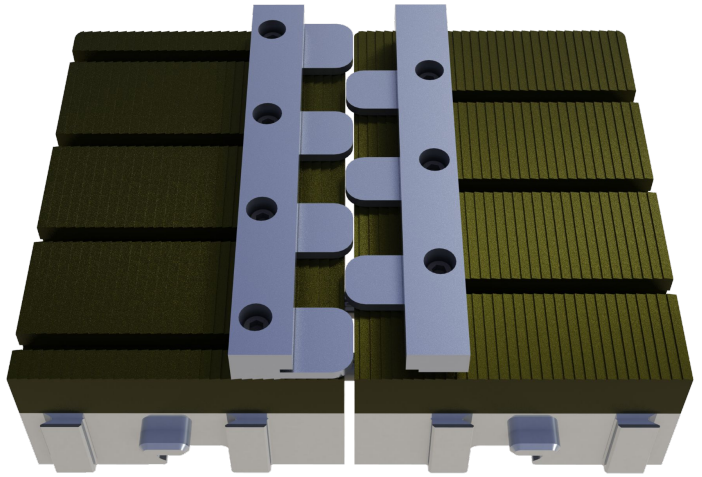
- When the shape of the part and the OP 2 jaws cannot adequately locate the part in Y during clamping, additional measures are needed
- There are two options available for locating rectangular parts in Y:
  - Building a Y datum into the OP 2 MultiGrip Jaws and using the Transfer Settle and Transfer Settle Angle options under the Advanced Configuration Options
  - Using a CNC probe to set the OP 2 CNC home location in Y
    - Requires a valid datum for the CNC probe to reach
    - Typically a through hole feature from OP 1 the probe can reach or a side profile that was machined in OP 1

Narrow Parts and Gripper or Vise Settle

- Generally, parts less than 1.625” wide cannot be settled using Gripper or Vise Settle with standard MultiGrip Jaws
- When the gripper opens, the gap between the jaws is 0.80” and the part may fall into the gap
- Adding an overlapping bridge into your MultiGrip Jaws or using Universal Top Jaws with VersaRails prevents the part from falling into the open gap during a settle operation
- The first example to the right shows 2 bridges bolted into place, then machined for clamping a 0.50” part
- The second example shows VersaRails in the 1.5” position (refer to the Universal Jaw Products manual for more information)



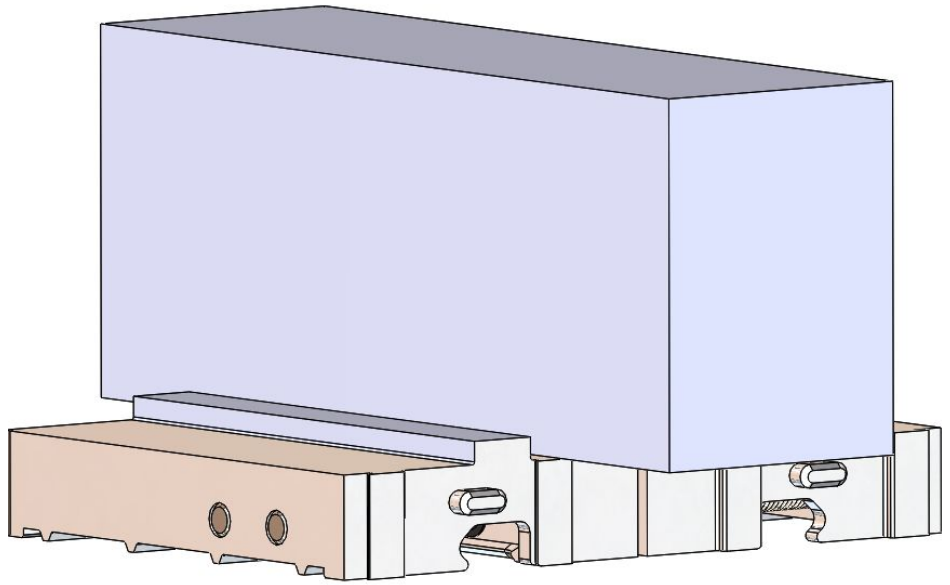
MultiGrip Jaws with 2 Bridges

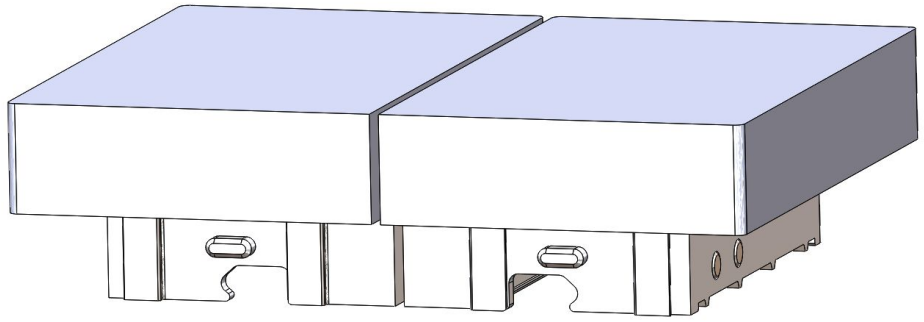


Universal Top Jaws with VersaRails

Accommodating Large Diameter and Long Parts

- Parts may overhang the front or back of the jaws
- Without a Y datum to locate against, the part will need to locate the Y datum using a Y-push
- Alternatively, oversized Top Plates can be used to better support larger parts





Using a CNC Probe

- A CNC spindle probe is a very useful tool for validating the automation process and can be used for the following purposes:
  - Automatically measure parts and perform tool wear offsets to keep parts in tight tolerance
  - Validate the positional accuracy of the part or MultiGrip jaws in the CNC machine before machining
  - Offset home position due to thermal changes or part load position for rectangular parts (generally OP 2 only, see next pages)
- Refer to CNC spindle probe documentation included with your machine for more information
- Remember that spindle probes require regular calibration to maintain high accuracy

Using a CNC Probe to Offset OP 1 in Y

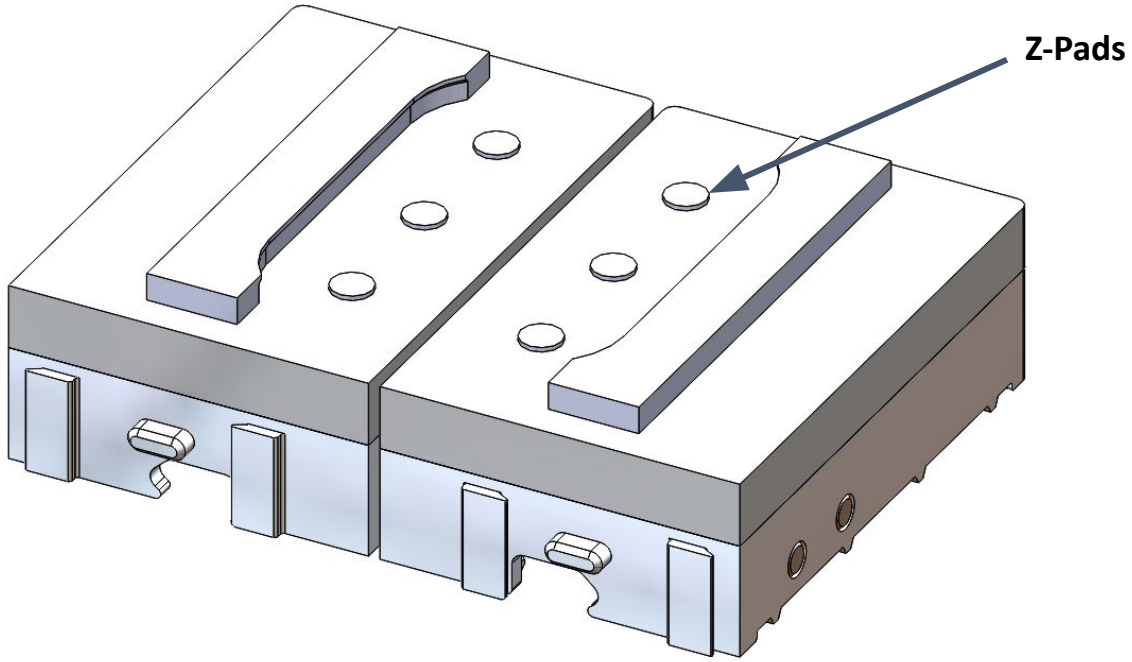
- In general, do not use a CNC Spindle Probe to offset the home location of a rectangular part in Y for OP 1
  - If the part is offset in Y and the OP 2 MultiGrip jaws locate the part along the Y axis (non-rectangular part), the robot may not be able to pick the offset part after OP 1 is complete because the part is shifted from the robot's center of pick
  - If the OP 2 jaws do not locate the part in Y, the part may be offset in Y using a probe in OP 1
- For raw stock that is cut very closely to nominal length, combining an OP 1 Y Push with a probe **is typically OK** because the true position of the part is only offset a very small amount

Jaw Durability

- MultiGrip jaw components are made from 6061-T6 aluminum for a good balance between low weight and durability
- When machining harder materials, additional considerations may be required for long jaw life:
  - Will the jaw pocket walls deform from hard part materials under vise clamping pressure?
    - If the clamping surfaces of the part are smooth and total vertical wall clamping surface area of the jaw pocket is greater than 1” squared, bare aluminum will generally suffice
    - Otherwise, we recommend a jaw pocket be made from hardened steel and bolted to the jaws as an insert
  - Will chips from the cutting process strike critical portions of the jaws with enough force to wear the jaws?
    - Hard anodizing the MultiGrip Top Jaws or the use of a hardened steel insert will generally manage wear issues

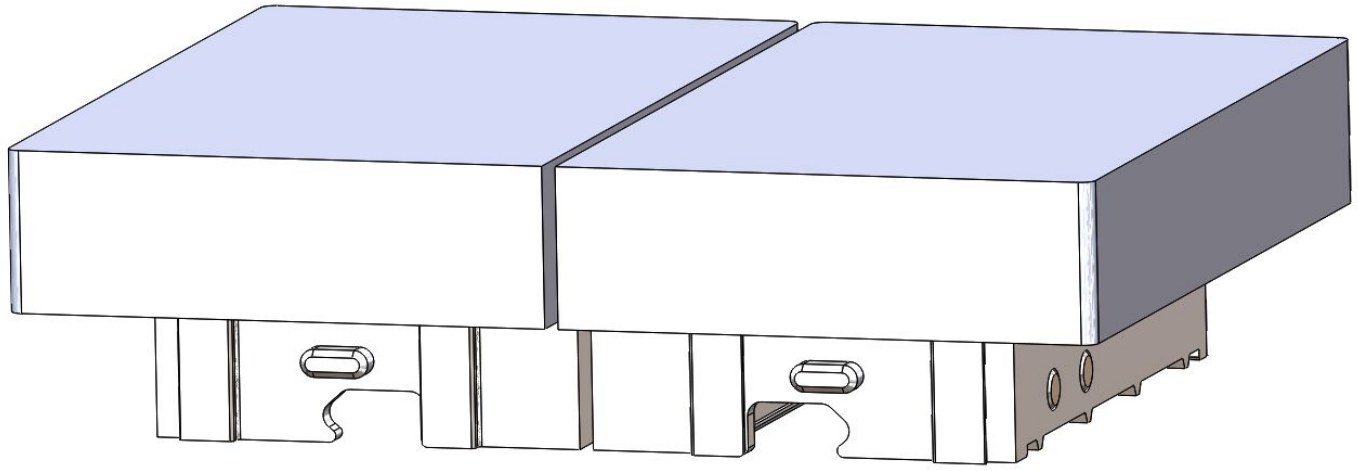
Part Release During Place to Outfeed

- Lighter parts with lots of surface area between the part and jaws in a machining environment that uses coolant may not release from the jaws during place
- When machining lighter parts with large surface areas, minimize surface contact between part and jaws
- Use “pads” in Z and X clamping surfaces as necessary to reduce surface area:



Using Over-Sized Top Jaws

- Oversized Top Jaws are two inches wider and two inches longer than standard Top Jaws
- Can be used to better support larger parts during the CNC machining process
- Available from your dealer or VersaBuilt direct



Preparing to Automate a New Part

Section 5

Preparing to Automate a New Part

Steps to automate a new part:

1. Prove out machining of the part by hand loading
2. Determine pick, transfer and place heights from CAD or physically measure
3. Weigh jaws and parts
4. Configure Jaws and Part in VSC
5. Setup and Run Job

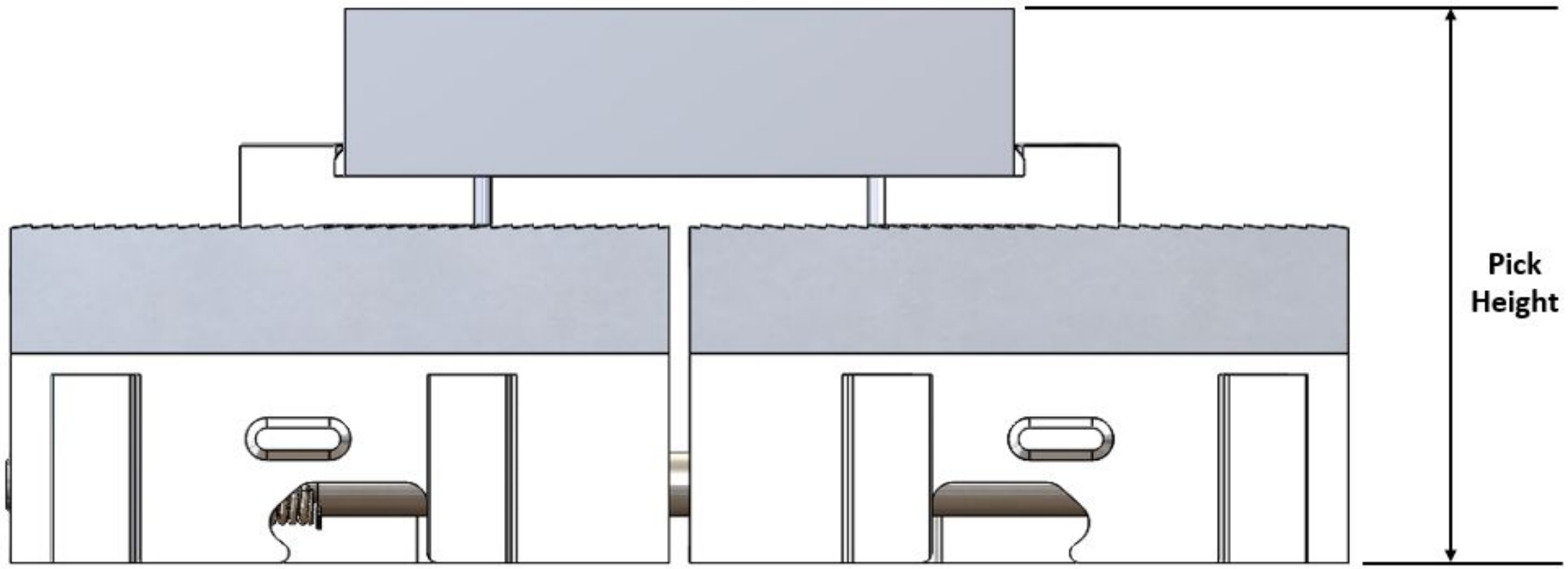
Prove out Machining

- Design first op and second op jaws according to the MultiGrip Machinist's Manual
- Validate CNC process is functioning as expected by hand loading parts into jaws
- After first operation is complete, weigh and record half-completed part for next step
- After second operation is complete, weigh and record completed part for next step

Determine Pick Height

- Measure Pick Height from CAD

  **Optionally, jaws and parts can physically be measured with a height gauge*
- Pick height is measured from the bottom of the MultiGrip Jaw to the top of the raw material
- **Tip:** Enable Part Find on Pick is an option in the part configuration that uses the robots force sensors to find the part height more accurately

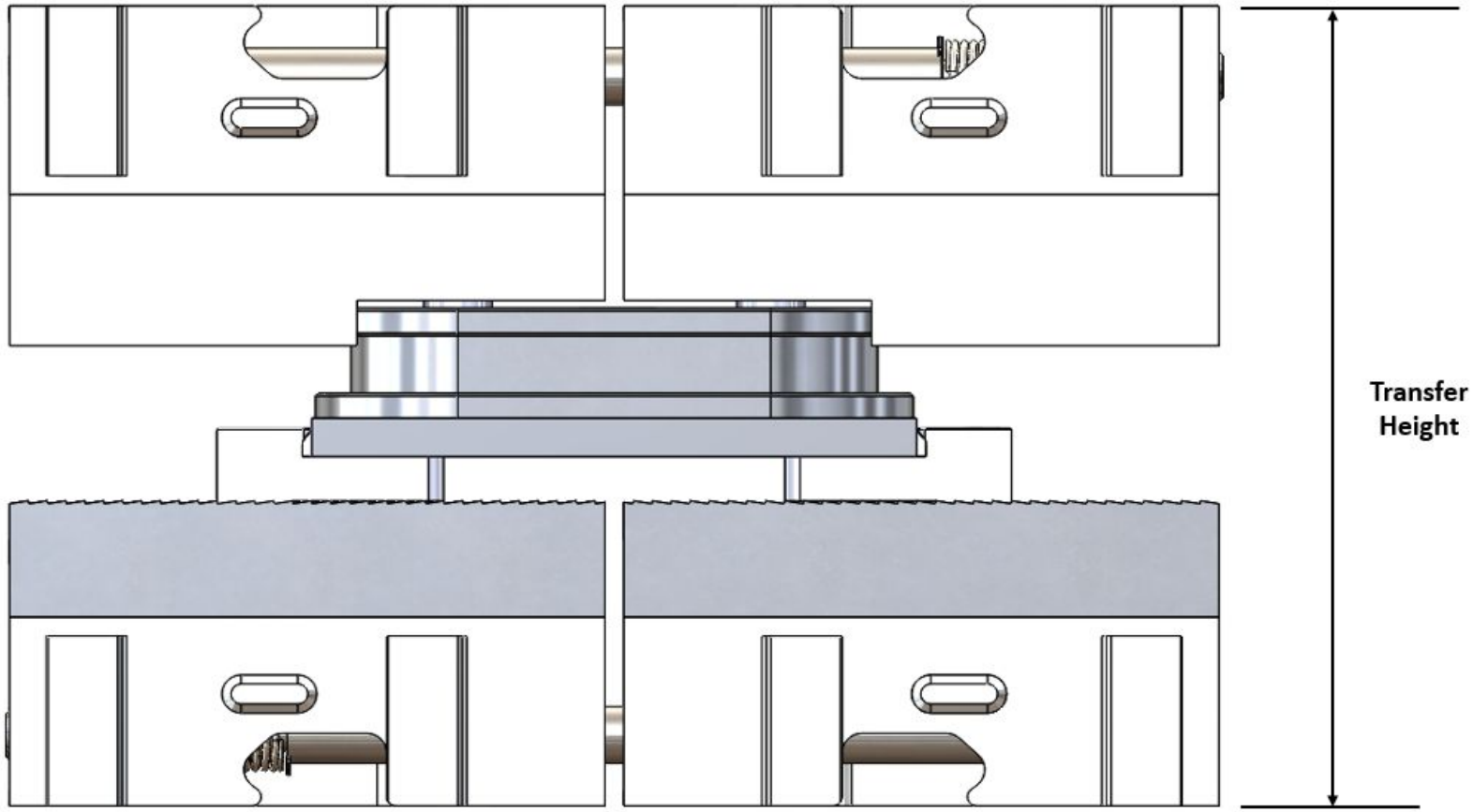


Determine Transfer Height

- Measure Transfer Height from CAD

  Optionally, jaws and parts can physically be measured with a height gauge

- Transfer height is measured from the bottom of the first op jaw to the bottom of the second op jaws with the after first op part (½ complete part) coincident with the Z locating surface of the second op jaws

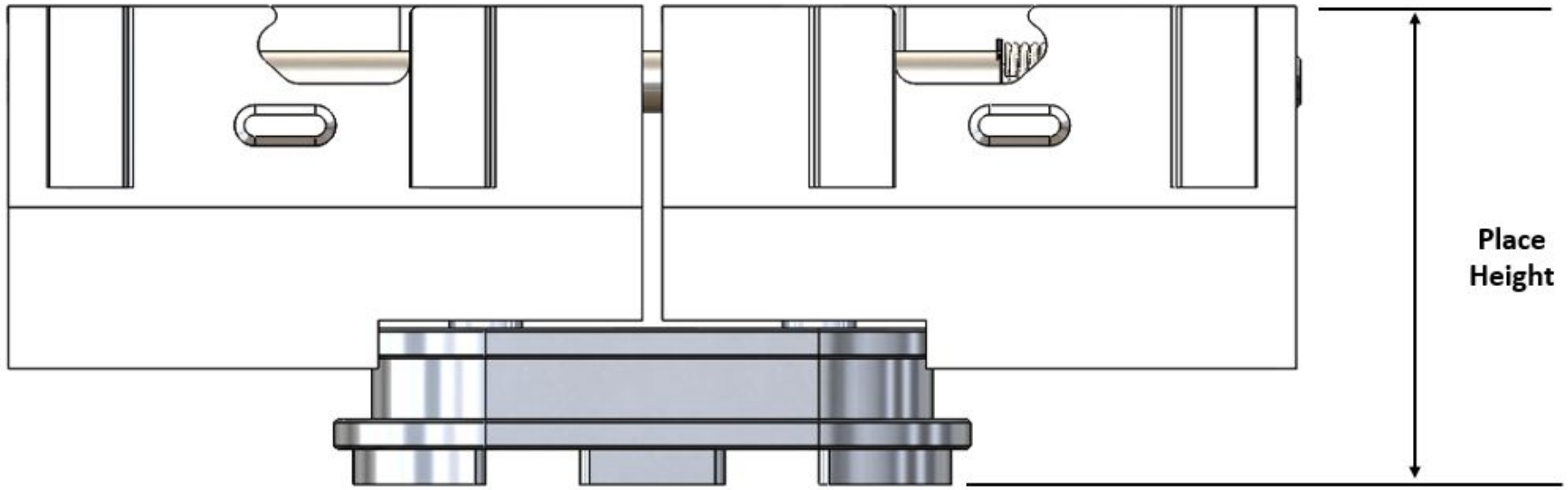


Determine Place Height

- Measure Place height from CAD

  Optionally, jaws and parts can physically be measured with a height gauge

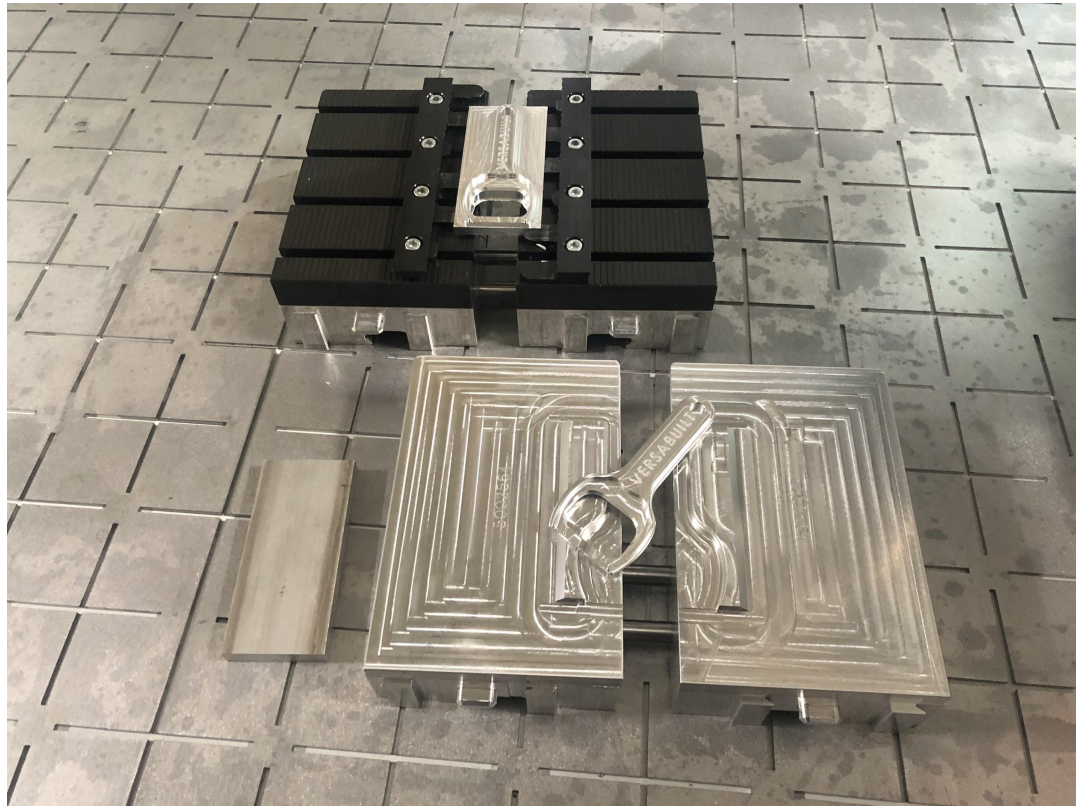
- Place height is measured from the bottom of the second op jaw to the top of the completed part



Preparing to Automate a New Part

Gather Jaw and Part weight information:

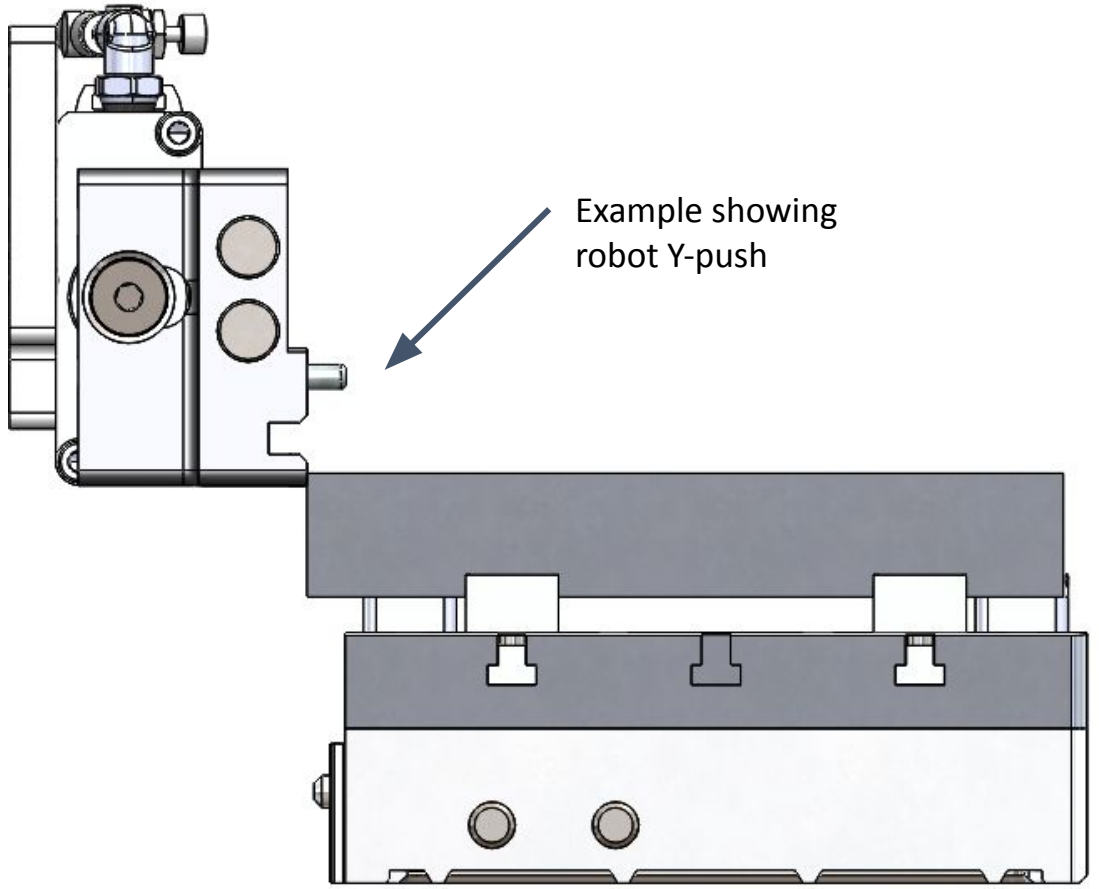
- First Op MultiGrip jaws weight
- Second Op MultiGrip jaws weight
- Weight of raw material before machining
- Weight of part after first operation machining is complete
- Weight of completed part



Preparing to Automate a New Part

OP 1/2 Part Y Locating Strategy:

- Generally only required for rectangular parts
- If part will require Y Locating after OP 1 or OP 2 load, determine whether the process will be best served by a Y push or a datum in the jaws and a pick settle angle



Creating Jaws and Part Configurations

Section 6

Connect to the VSC

Configure Robot for VSC (robot dependent)

Some robots require a VersaBuilt program to be run on the robot's teach pendant or the robot to be put in a special mode for the VSC to be able to control the robot.

Review the **VersaBuilt Robot Installation, Configuration and Operation** manual that matches your robot make and model for possible additional steps required to enable operation with the VSC.

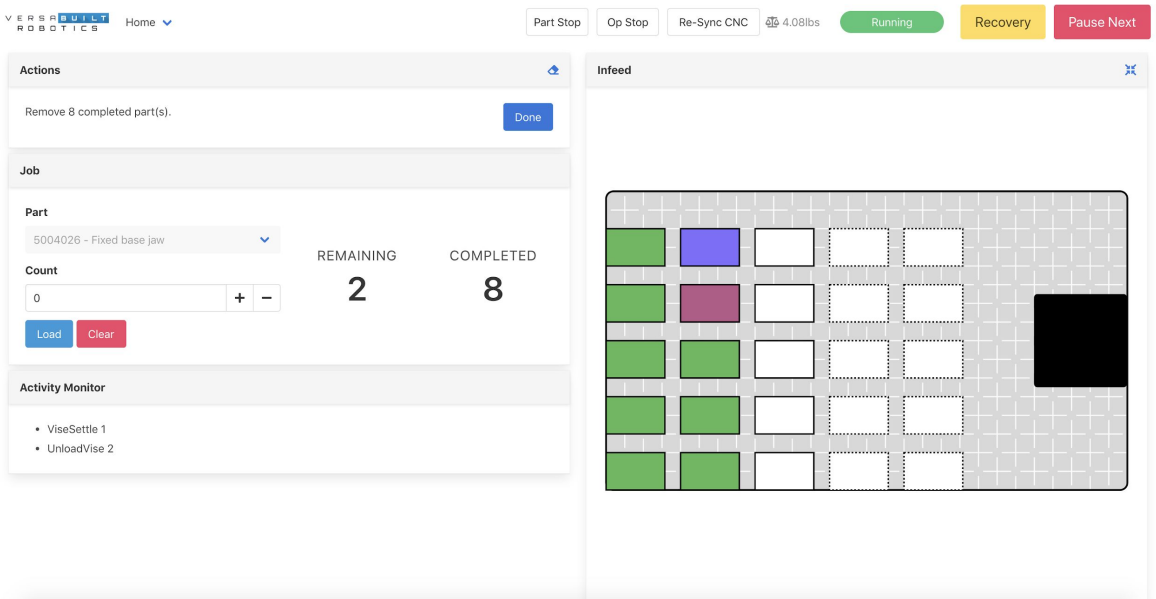
Open the VSC Home Page

The VSC is accessed by a phone, tablet or computer.

Using a phone, tablet or computer, open the **VSC web page** using the following address:

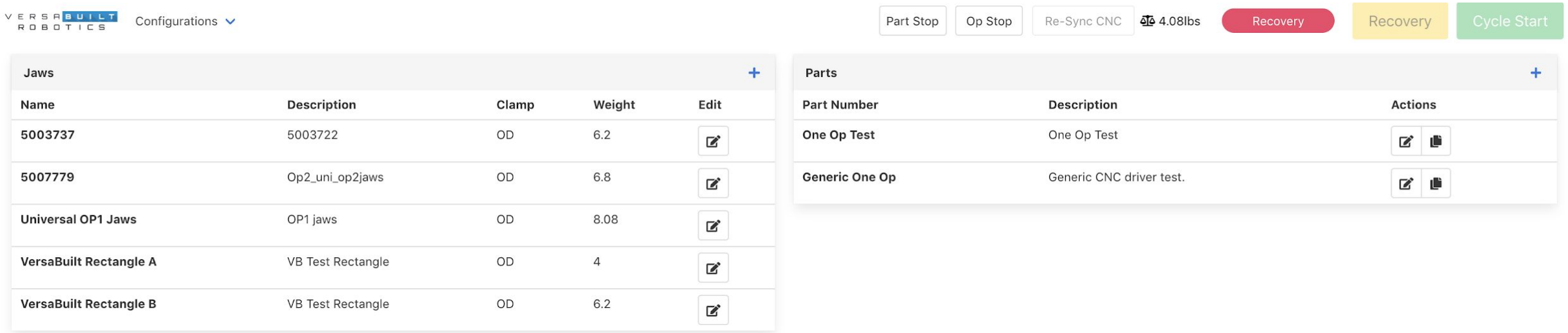
192.168.4.1:9000 *for Wifi* connected devices
192.168.2.1:9000 f*or Ethernet* connected devices

*For more information on how to configure the device networking to access the VSC, see the VSC Mill Operators Manual.



Wifi connection is vsc + serial number (e.g., vsc00125)
Wifi password = versabuilt

VSC Configurations

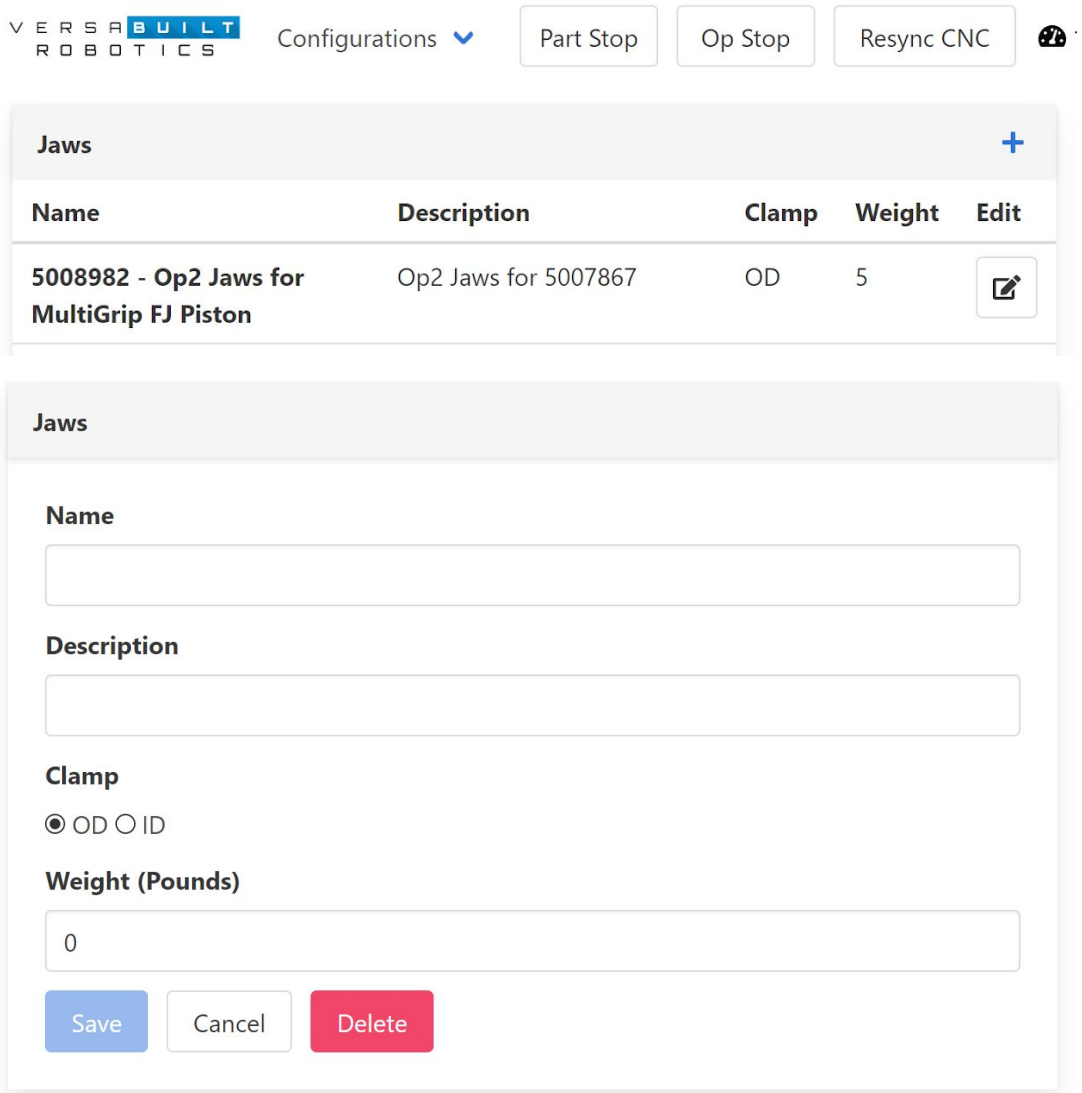


The VSC Configurations page allows MultiGrip Jaws and Part configurations to be stored in the VSC

Jaws are configured separately from Parts because MultiGrip Jaws can be used by more than one part configuration

Once a Part configuration is complete, it can quickly be recalled at any time by the operator from the Home screen

VSC Jaw Configurations



A new Jaw configuration is created by clicking on the + in the upper right corner of the Jaws panel

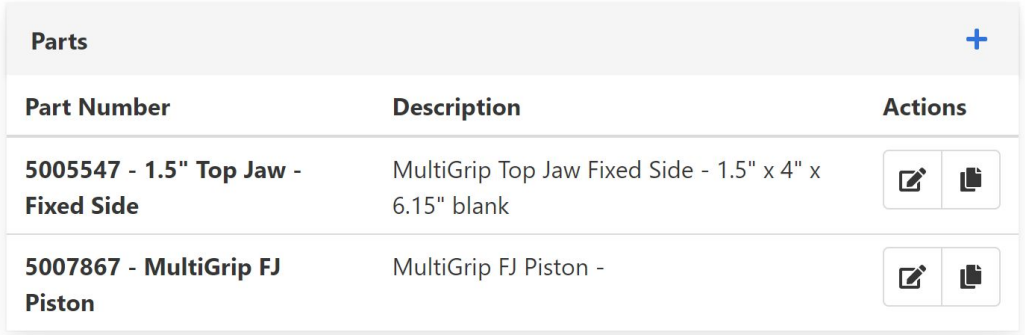
Name: Identifier used to select the jaw in the part configuration

Description: Additional text to display to the user

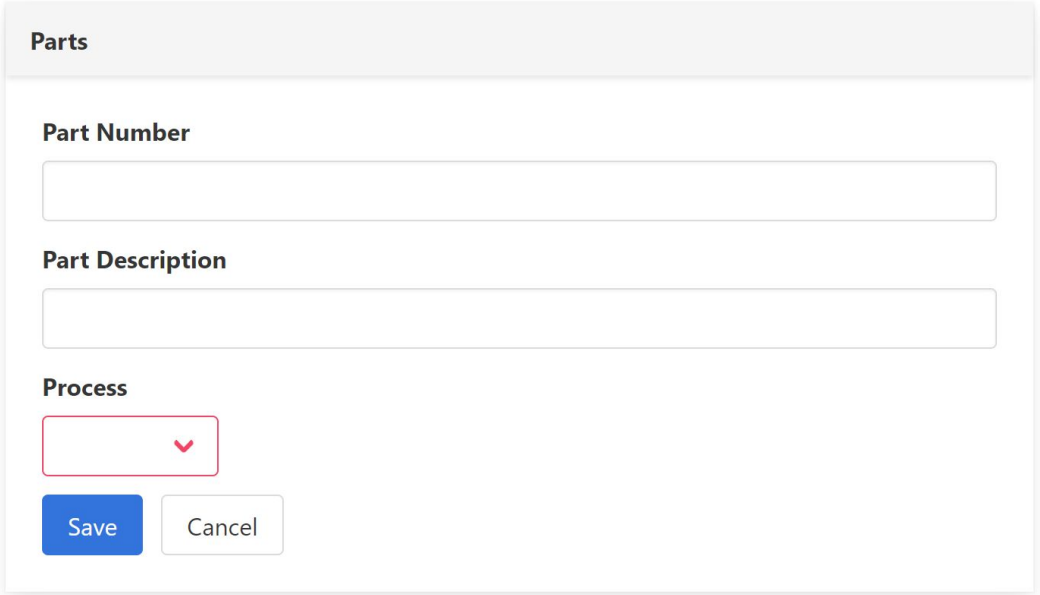
Clamp: Identify if the jaws use OD (Outer Diameter) or ID (Inner Diameter) clamping

Weight: Weight of the jaws

VSC Part Configurations



A new Part configuration is created by clicking on the + in the upper right corner of the Jaws panel



Part Number: an identifier used by the operator to select the part to run in the Jobs Panel

Part Description: a description of the part

Process: the script used to process the part; included process script parameters are described on the following pages

VSC Process Scripts

VSC Process Script Overview

VSC Process Scripts drive how the Mill Automation Kit moves parts through the automation process. VSC Process scripts include parameters entered in the part configuration and how the VSC uses those parameters to coordinate robot motion, IO and CNC processing.

The Mill Automation Kit comes with Process Scripts for one operation parts, two operation parts and a Process Script to test picking/placing in the infeed. If you're automation application has special requirements, contact VersaBuilt for a quote on a custom Process Script.

One Op and One Op Generic Process Scripts

These Process Scripts are used for one milling operation parts; that is parts that will have a single milling operation performed per part. The One Op Generic Process script is used with the Generic CNC driver.

Two Op and Two Op Generic Process Scripts

These Process Scripts are used for two milling operation parts; that is parts that will have a milling operation performed on one side of the part and another milling operation performed on the opposite side of the part. The Two Op Generic Process script is used with the Generic CNC driver.

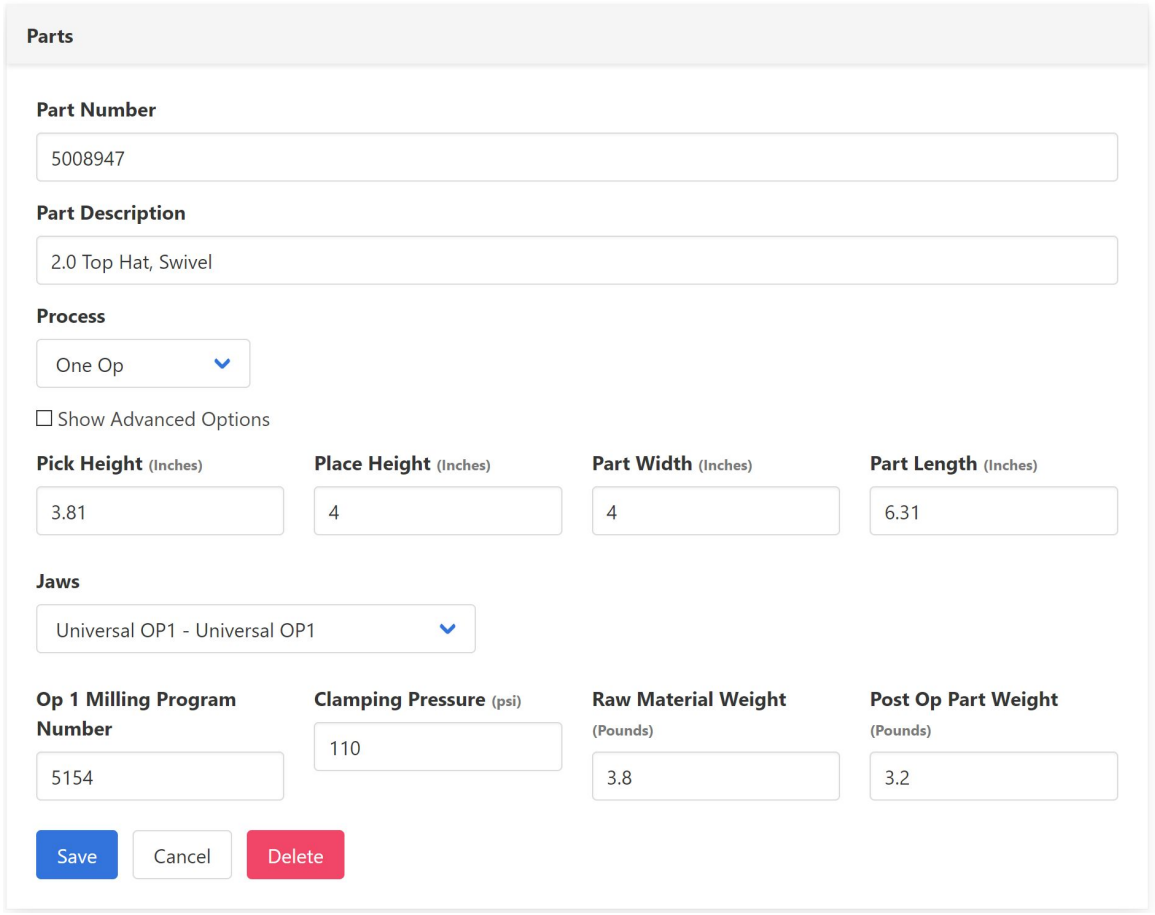
Test All Slots Process Script

The Test All Slots Process Script is used to validate picking/placing in the infeed after calibration of the table.

Show Advanced Options

By default, Process Scripts show the basic information required to implement the process, advanced options are set to default values. To show advanced options, click on the Show Advanced Options button.

One Op Process - Standard Options



Pick Height: pick height measured from the bottom of the inverted MultiGrip Jaws to the table (see Machinists Manual)

Place Height: place height measured from the bottom of the MultiGrip Jaws to the table (see Machinists Manual)

Part Width: width of the part before processing

Part Length: length of the part before processing

Jaws: MultiGrip Jaws to be used in the process

One Op Process - Standard Options

Op 1 Milling Program Number: CNC program number used to mill the part (**not in Generic version**)

Clamping Pressure: set the air pressure of the vise (requires VSC Programmable Pressure option)

Raw Material Weight weight of the part before milling

Post-Op Part Weight: weight of the part after milling

One Op Process - Advanced Options

Enable Part Find on Pick: when enabled, robot stops 10mm above part and moves down slowly looking for a change in force to detect jaws in contact with part. Defaults to enabled.

Bin Drop: when enabled, when a part is complete, the part is released at the calibrated Bin Drop location instead of at the pick location in the infeed. Defaults to disabled.

Y Push: option to have the robot push the part to center in the vise; typically used with a -0.25” Y infeed offset (see Machinists Manual)

Infeed Y Offset: option to offset the pick of the part along the Y axis (clamping axis) of the jaws; typically used for a Y push to center operation in the CNC (see Machinists Manual)

Y Push Height Offset: offset from the top of the part the gripper will move down to push the part to center

CNC Table Load Program: CNC program number used to position the table for loading by the robot. Defaults to 8000.

One Op Process - Advanced Options

CNC Vise Wash Program: CNC program number used wash the vises of chips and position the table for loading by the robot. Defaults to 8001.

Vise: vise number to load the jaws and part for processing by the CNC in Op 1. Defaults to 1.

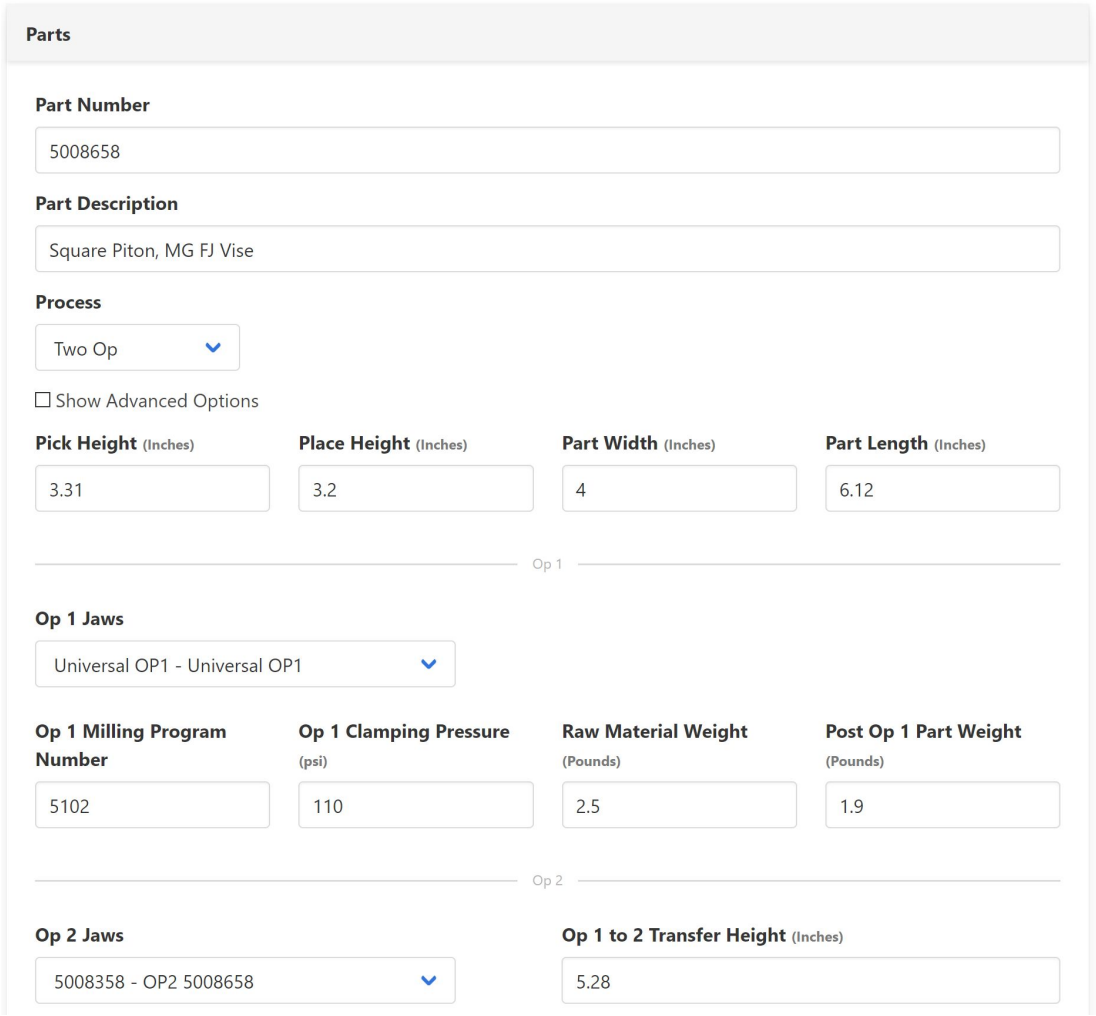
Robot Settle: option to have the robot open and close the jaws to allow the part to settle in Z and/or against a Y datum (see Machinists Manual). Defaults to enabled.

Robot Settle Angle: angle in degrees the robot will rotate the MultiGrip Jaws about X to settle the part against a Y datum in the jaws (see Machinists Manual). Defaults to 0.

Vise Settle: option to unclamp then clamp the part after loading in the vise to settle the part in Z (see Machinists Manual). Defaults to enabled.

Empty Jaws Blow Off: when enabled, after placing a completed part, robot will blow off the jaws before picking the next part. Defaults to enabled.

Two Op Process - Standard Options



Pick Height: pick height measured from the bottom of the inverted MultiGrip Jaws to the table (see Machinists Manual)

Place Height: place height measured from the bottom of the MultiGrip Jaws to the table (see Machinists Manual)

Part Width: width of the part before processing

Part Length: length of the part before processing

Op 1 Jaws: MultiGrip Jaws to be used in the Op 1 milling operation process

Two Op Process - Standard Options

Op 1 Milling Program Number: CNC program number used to mill the part in Op 1 (**not in Generic version**)

Op 1 Clamping Pressure: set the air pressure of the vise during Op 1 milling (requires VSC Programmable Pressure option)

Raw Material Weight weight of the part before milling

Post-Op 1 Part Weight: weight of the part after Op 1 milling is complete

Op 2 Jaws: MultiGrip Jaws to be used in the Op 2 milling operation process

Op 1 to 2 Transfer Height: total stack height, from bottom of Op 1 jaws to bottom of inverted Op 2 jaws for the Op 1 to Op 2 pick (see Machinists Manual)

Op 2 Milling Program Number: CNC program number used to mill the part in Op 2 (**not in Generic version**)

Op 2 Clamping Pressure: set the air pressure of the vise (requires VSC Programmable Pressure option)

Post-Op 2 Part Weight: weight of the part after Op 2 milling is complete

Two Op Process - Advanced Options

Enable Part Find on Pick: if enabled, robot stops 10mm above part and moves down slowly looking for a change in force to detect jaws in contact with part before clamping. Defaults to enabled.

Bin Drop: if enabled, when a part is complete, the part is released at the calibrated Bin Drop location instead of at the pick location in the infeed. Defaults to disabled.

Y Push: option to have the robot push the part to center in the vise; typically used with a -0.25” Y infeed offset (see Machinists Manual)

Infeed Y Offset: option to offset the pick of the part along the Y axis (clamping axis) of the jaws; typically used for a Y push to center operation in the CNC (see Machinists Manual)

Y Push Height Offset: offset from the top of the part the gripper will move down to push the part to center

CNC Table Load Program: CNC program number used to position the table for loading by the robot. Defaults to 8000.

Two Op Process - Advanced Options

CNC Vise Wash Program: CNC program number used wash the vises of chips and position the table for loading by the robot. Defaults to 8001.

First Vise: vise number to load the jaws and part for processing by the CNC in Op 1. Defaults to 1.

Robot Settle: option to have the robot open and close the jaws to allow the part to settle in Z and/or against a Y datum (see Machinists Manual). Defaults to enabled.

Robot Settle Angle: angle in degrees the robot will rotate the MultiGrip Jaws about X to settle the part against a Y datum in the jaws (see Machinists Manual). Defaults to 0.

Vise Settle: option to unclamp then clamp the part after loading in the vise to settle the part in Z (see Machinists Manual). Defaults to enabled.

Op 1 Empty Jaws Blow Off: when enabled, after the Op 1 to Op 2 transfer, robot will blow off jaws.

Fundamentals of Successful Automation

Section 7

CNC Process vs Automation Process

The CNC process and the automation process rely on each other for success. The CNC process requires the automation process to:

- Control the automation steps and command robot movements, gripper, vises, CNC doors and execution of CNC programs
- Load the jaws and parts into the CNC vises
- Precisely locate each part in the jaws (CNC process may also control part location)

The automation process requires the CNC process to:

- Wash the vises, jaws and parts of all chips
- Keep the CNC door mechanism free of chips or other debris that could prevent the door from opening or closing
- Remove chips as required to prevent the CNC process from stopping

Automation Process Errors vs CNC Process Errors

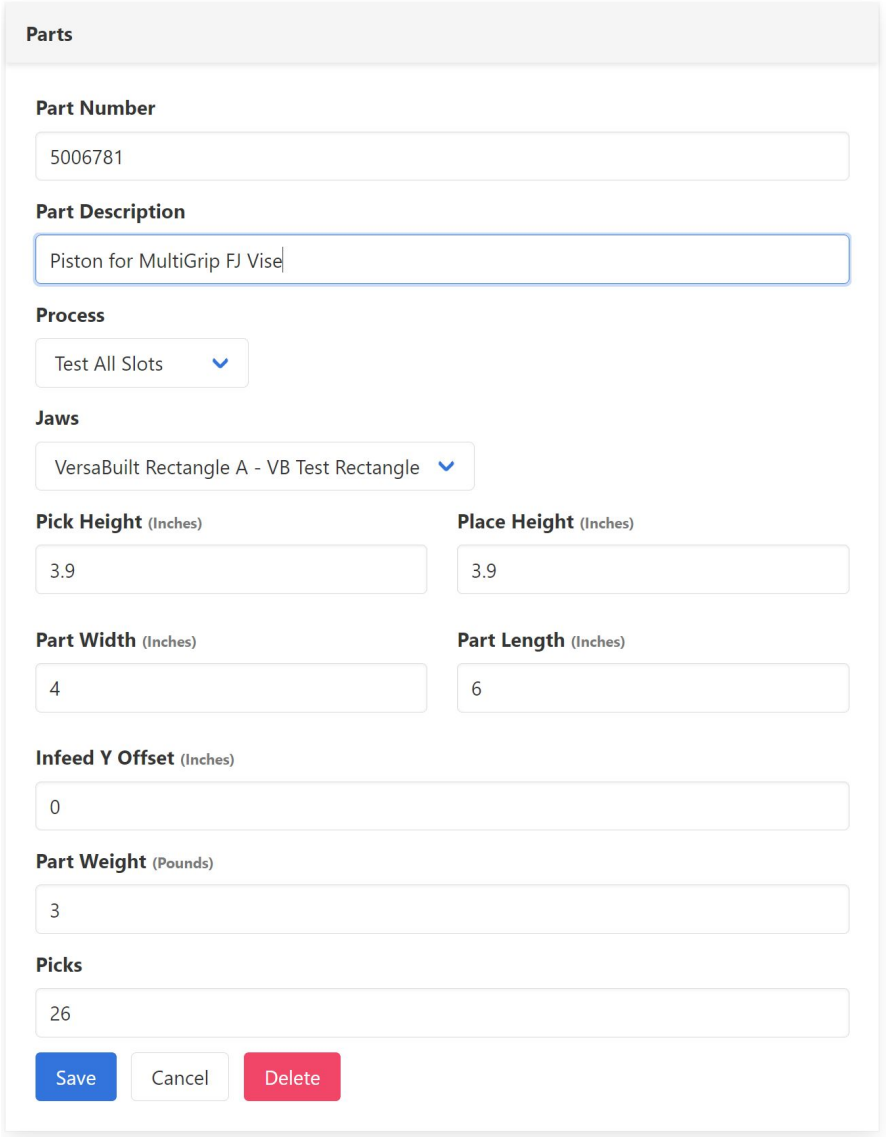
Automation Process Errors and Typical Causes

- Missed robot pick or missed robot place of a part
  - Part not properly located in the infeed
  - Part dimensional variability (eg part shorter than expected)
  - Poor robot calibration or accuracy
  - Change in air pressure to gripper or vise
- Failure to load or unload a vise
  - Inadequate CNC vise wash program or VersaBlast
  - Poor calibration
  - Robot cart or CNC moved since robot was calibrated
  - Robot that is cold and doesn't accurately move to the expected position
- Failure to properly locate a part or jaws in vise
  - Inadequate CNC vise wash program or VersaBlast
  - Damaged jaws
  - Poor jaw design
  - Variability in part dimensions or other variables
- Robot stop
  - Unexpected collision
  - Actual robot payload significantly different than programmed payload

CNC Process Errors and Typical Causes

- CNC door fails to open or close
  - Chips not adequately washed away from critical door components
  - Inadequate maintenance
- Unexpected chips or coolant on the floor
  - Inadequate maintenance
  - Lack of understanding in maintenance intervals
- Broken cutting tools
  - Lack of understanding tool life
  - Inadequate coolant system maintenance
  - Tool holder problems
  - Poor jaw design
  - Change in air pressure to vise
- Parts that fail to meet dimensional tolerances
  - Tool life management problems
  - Inadequate jaw design
  - Change in air pressure to vise
  - Inadequate CNC vise wash program or VersaBlast

Validating the Automation Processes

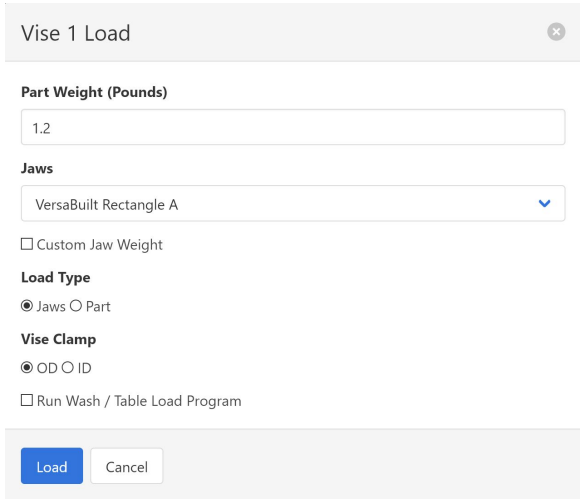


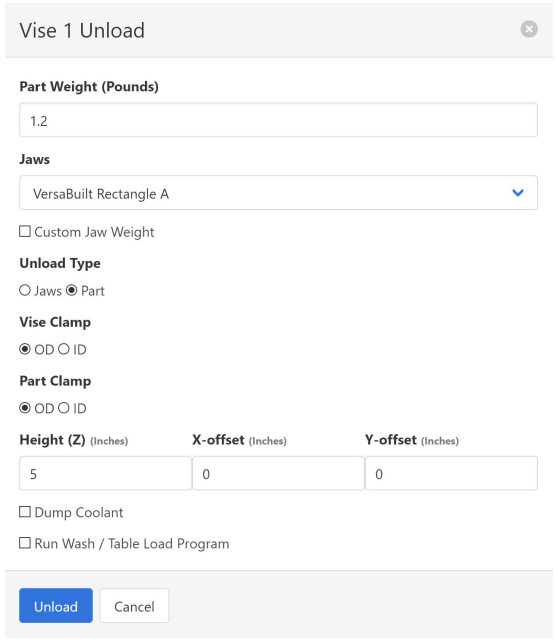
The Mill Automation Kit basic functions should have been validated as part of the installation process. This includes validating all IO and the calibration of the system. Additional validation tools are available that allow the automation process to be validated on a per part basis. VersaBuilt recommends using these tools as the first parts are automated to gain confidence in the automation process.

Test All Slots

Test All Slots is a process script that simply picks and places a single part through the infeed. To use Test All Slots to validate picking all locations in the infeed, enter and save a part configuration using the Test All Slots process. For the Picks parameter, enter the number of pick locations to test. Hand-load the MultiGrip jaws on the robot gripper, place a single piece of raw material into the first slot and press Cycle Start. The robot will pick the raw material from the first slot and place it into the second slot, continuing for the number of Picks specified in the configuration. Observe that the robot is able to pick each location and has ample margins between the part and jaws in the pick.

Validate the Automation Processes



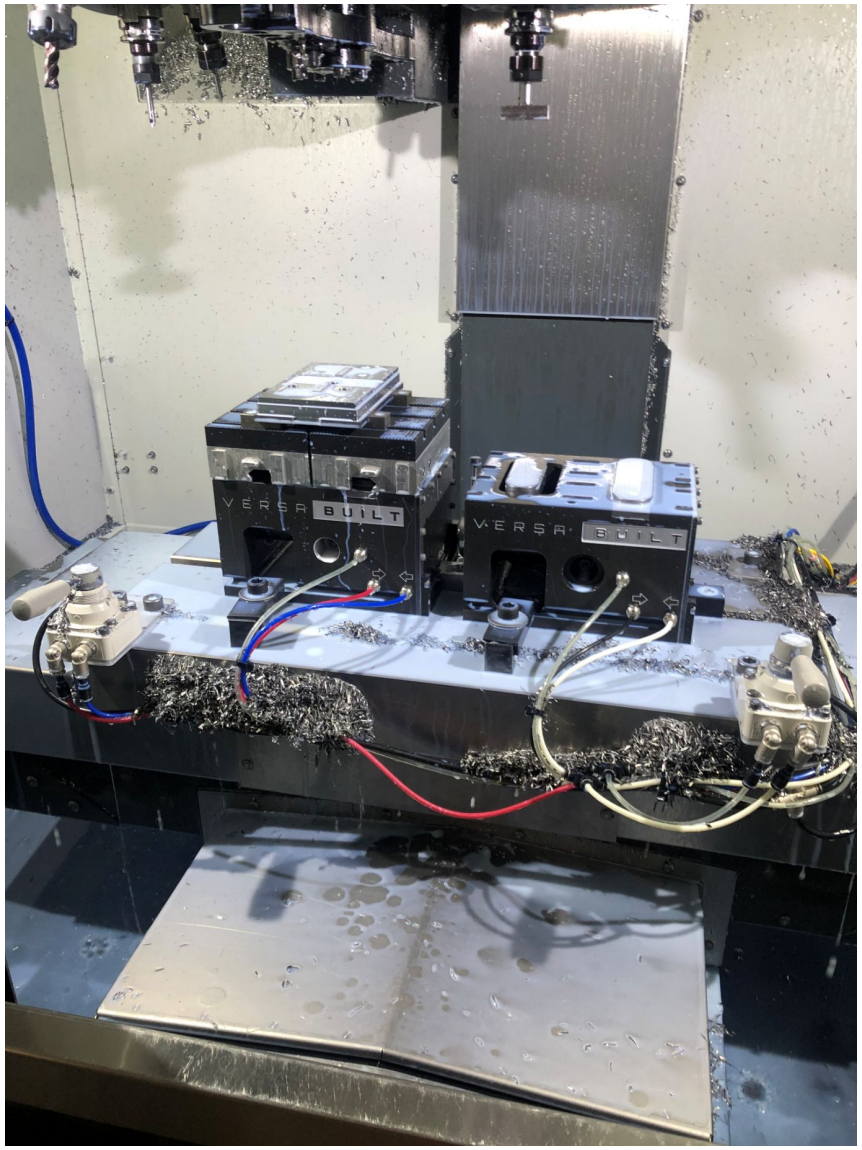


Load Vise, Unload Vise and Unload Part

Vise functions can be validated from the Recovery panel. Load Vise and Unload Vise are part of system validation and generally only need to be validated as part of the installation process.

Vise Unload Part is part of the Automation Process validation for each part. Place the Op 1 jaws in the vise with a part that has completed the first milling operation. Place the Op 2 jaws in the robot gripper. Press the Unload button in the Recovery panel under the vise holding the Op 1 jaws. Under the Unload Type, select Part. Enter all information including part weight, Jaws (in the robot gripper), vise and part clamp type and height of the Unload Part pick. The height of the Unload Part pick is measured from the bottom of the jaws on the vise to bottom of the jaws in the robot gripper in the inverted state over the part. Verify the robot picks the part with good margins on the gripping.

Validate the CNC Processes



There are three components of the CNC Process that need to be validated and measured:

- Validate that the CNC Process (vise wash program) leaves the part, vises and the gripper interface of the jaws free of chips
- Measure how long the CNC Process can operate before operator maintenance is needed to prevent an unexpected event (eg overflowing chip bin, stuck CNC door, etc)
- Measure how long the machining process can operate before operator intervention is required to ensure parts meet required dimensions

Understanding how long the automation process can run without operation intervention is critical in preventing undesirable results from your automation system.

Validate the CNC Processes - Vise Wash Program

The importance of the vise wash program is easy to overlook. The most important job of the vise wash program is to make sure that chips created in the machining process do not cause a problem in the automation process. A sample vise wash program is included with the Mill Automation Kit but it must be verified and customized for each application. The vise wash program must be continuously evaluated as new parts are added to the system. Different parts generate different types of chips and put those chips in different places.

After the vise wash program runs, there should be no chips on the top of the empty vise, no chips on the top of the part (after Op 1 in a two op process) and no chips on the gripper interface of the MultiGrip jaws.

The vise wash program should select a tool that will not collide with parts and jaws as the table is moved. Generally, flood coolant is sufficient to wash away all chips. If through spindle coolant is available, a tool should be selected that provides maximum flow of coolant rather than a small high-pressure stream. Sometimes no tool in the spindle works best.

Validate the CNC Processes - Operator Maintenance Intervals

All CNCs require operator maintenance to prevent “unexpected events”. If operators perform CNC maintenance primarily by reacting to what they observe, “unexpected events” are much more likely to occur when automation is implemented. When automation is implemented, operators spend less time interacting with the CNC process making them less likely to observe a problem. If lights-out manufacturing is implemented, scheduled maintenance becomes even more critical.

Operator maintenance includes tasks like:

- Adding coolant and check coolant concentrations
- Emptying chip bins
- Cleaning coolant sump and filters
- Cleaning coolant lines of chips
- Washing down chips in the CNC cabinet and CNC door mechanisms
- Way and spindle lubrication

VersaBuilt recommends instituting maintenance intervals with a sign-off sheet. Make sure the automation does not run past any maintenance interval to avoid “unexpected events”.

Validate the CNC Processes - Machining Process

Like CNC maintenance, the machining process has limits to how long it can continue without operator intervention. Tool life management is the primary factor influencing how long the machining process can operate without intervention. An entire book could be devoted to tool life management.

Tool life management generally falls into one of two categories: operator observation or process-driven proactive management. Process-driven proactive tool management takes time to develop and increases in difficulty in high-mix manufacturing environments. If proactive tool life management is used in conjunction with a CNC's built-in tool expiration (the CNC alarms when a tool expires), the CNC will prevent the automation process from continuing when tool life expires.

If tool life is managed by operator observation, the operator must decide how many parts can run before further operator inspection is required.

Validate the CNC Processes - Tool and Spindle Probes

Tool and spindle probes can be a very valuable tool for high-mix CNC automation if their limits are understood.

Tool probes can be used to measure the tool length and diameter and can be used for tool breakage detection. Generally, length and diameter work best for measuring new tools but often cannot be relied upon for measuring worn tools. As tools wear, dimensional changes in the part tend to be driven primarily by the cutting edges getting dull and tool deflection rather than the diameter or the length of the tool changing. Using a tool probe for tool breakage detection is slower than other options for tool breakage but generally works well.

A spindle probe is an excellent tool for high-mix CNC automation. A spindle probe can measure critical part features in-process and automatically update tool wear offsets. This can increase the time the machining process is able to run without operator intervention. A spindle probe can also be used as a “dynamic” tool life monitor. You may find that when a tool reaches for example 0.001” of total wear offset from new, the tool is ready to expire.

Successful Lights-Out Manufacturing

Many companies purchase CNC automation for “lights-out” manufacturing. Before venturing into “lights-out” manufacturing, validate your automation and CNC processes and measure and understand how long your automation can run successfully without an operator present. Hope and automation are two things that don’t go well together.

Although “lights-out” manufacturing may be the goal, understand that CNC automation can provide a great return on investment even if it only works when operators are present to monitor it. CNC automation is primarily a tool that increases the productivity of operators.

In motorcycle racing, you sometimes hear the phrase, “You need to slow down to go faster”. The same can be said for CNC automation. Machinists are typically taught to optimize the speed of the machining process. In high-mix automation, it is more important to optimize the length of time the machining process can run without operator intervention. In addition to making choices about tool and spindle probing, machinists can sometimes make choices in machining and workholding strategies that improve process reliability over process speed. Best to find a balance between speed and reliability with a strong emphasis on reliability.

Appendices

One Op Part Configuration Worksheet

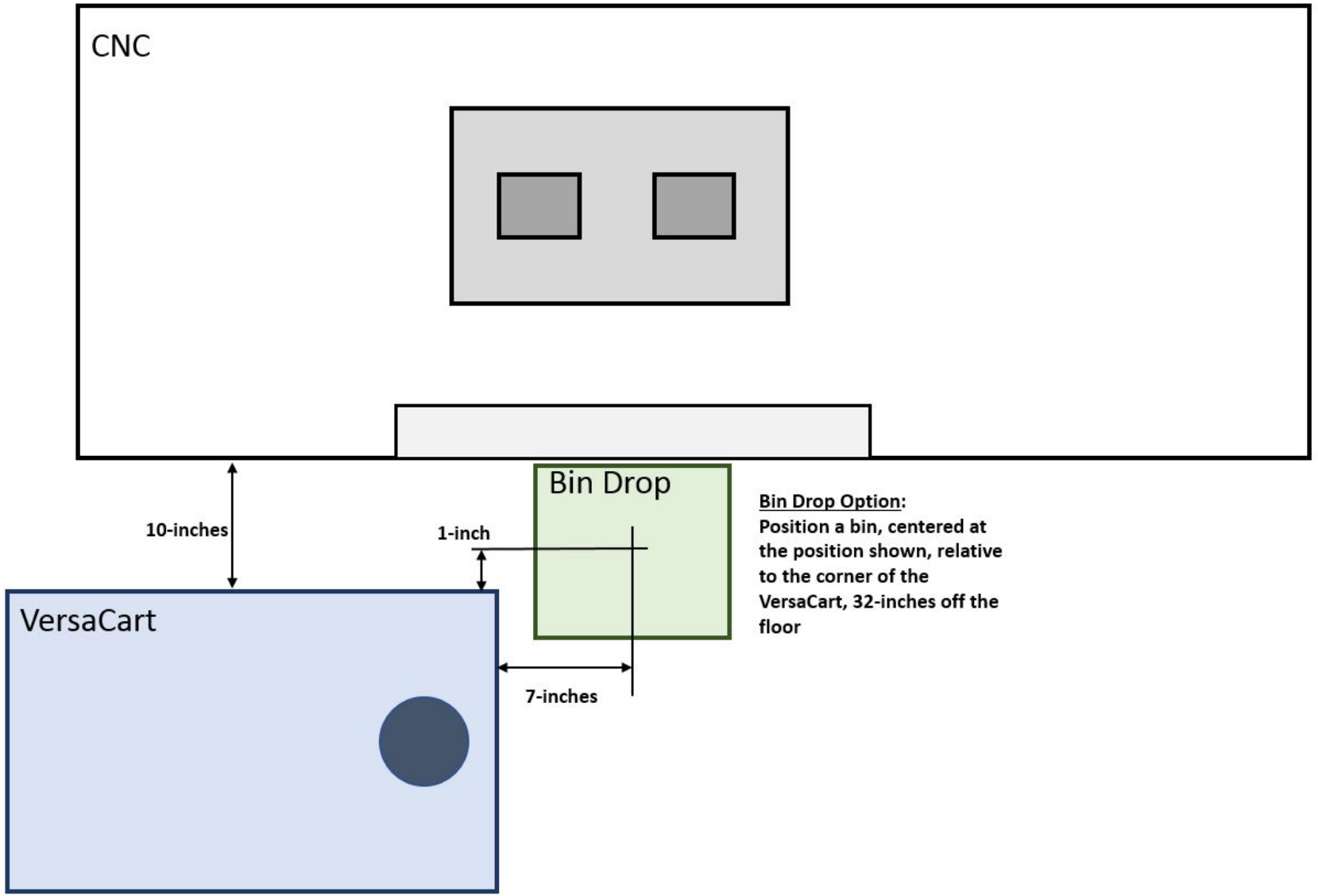
Part Number			
Part Description			
Process			
Enable Part Find on Pick	True / False	Bin Drop	True / False
Pick Height		Place Height	
Part Width		Part Length	
Y Push	True / False		
Infeed Y Offset		Y Push Height Offset	
CNC Table Load Program		CNC Vise Wash Program	
Jaws		First Vise	
Robot Settle	True / False	Vise Settle	True / False
Robot Settle Angle		Empty Jaws Blow Off	True / False
Op 1 Milling Program Number		Clamping Pressure	
Raw Material Weight		Post-Op Weight	

Two Op Part Configuration Worksheet

Part Number			
Part Description			
Process			
Enable Part Find on Pick	True / False	Bin Drop	True / False
Pick Height		Place Height	
Part Width		Part Length	
Y Push	True / False		
Infeed Y Offset		Y Push Height Offset	
CNC Table Load Program		CNC Vise Wash Program	
Op 1			
Op 1 Jaws		First Vise	
Robot Settle	True / False	Vise Settle	True / False
Robot Settle Angle			
Op 1 Milling Program Number		Op 1 Clamping Pressure	
Raw Material Weight		Post Op 1 Weight	
Empty Jaws Blow Off	True / False		
Op 2			
Op 2 Jaws		Transfer Height	
Robot Settle	True / False	Vise Settle	True / False
Robot Settle Angle			
X Vise Transfer Offset		Y Vise Transfer Offset	
Op 2 Milling Program Number		Op 2 Clamping Pressure	
Post Op 2 Weight			
Op 2 Part Blow Off	True / False	Op 2 Empty Jaws Blow Off	True / False

Bin Drop Option

- Place bucket or bin at location shown
- Protect parts with foam, water or other means



CNC Vise Control

- Each of the MutliGrip FJ Vises can be opened or closed from within a CNC program using the included CNC programs
- 9002 program is used for vise control
- Call the 9002 program using the G65 command and using D and C parameters:
  - D01. selects vise 1
  - D02. selects vise 2
  - C02. closes the vise
  - C03. opens the vise
- Recommend dwelling 1 second to allow vise to actuate:
  - G04 P1.

EXAMPLES:

- Close Vise 1: G65 P9002 D01. C02.
- Open Vise 1: G65 P9002 D01. C03.
- Close Vise 2: G65 P9002 D02. C02.
- Open Vise 2: G65 P9002 D02. C03.

VERSA BUILT
ROBOTICS