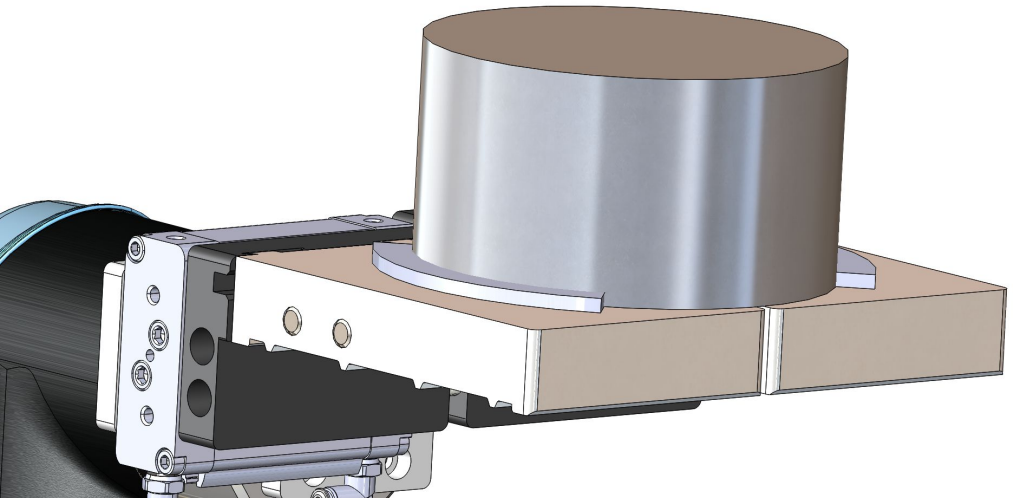
VERSA BUILT ROBOTICS



MultiGrip Machinist's Manual

Use and Applications

Table of Contents

Table of Contents

Safety

Section 1

Safety Warnings

Safety Warnings:

DANGER: MultiGrip components include pneumatic vises and grippers and are designed to work with robots and CNC machines. MultiGrip components may include sharp edges that pose laceration hazards. Pneumatic vises and grippers pose pinching and crushing hazards that can cause severe permanent injuries. Robots and CNC machines pose hazards that includes severe permanent injuries or even death.

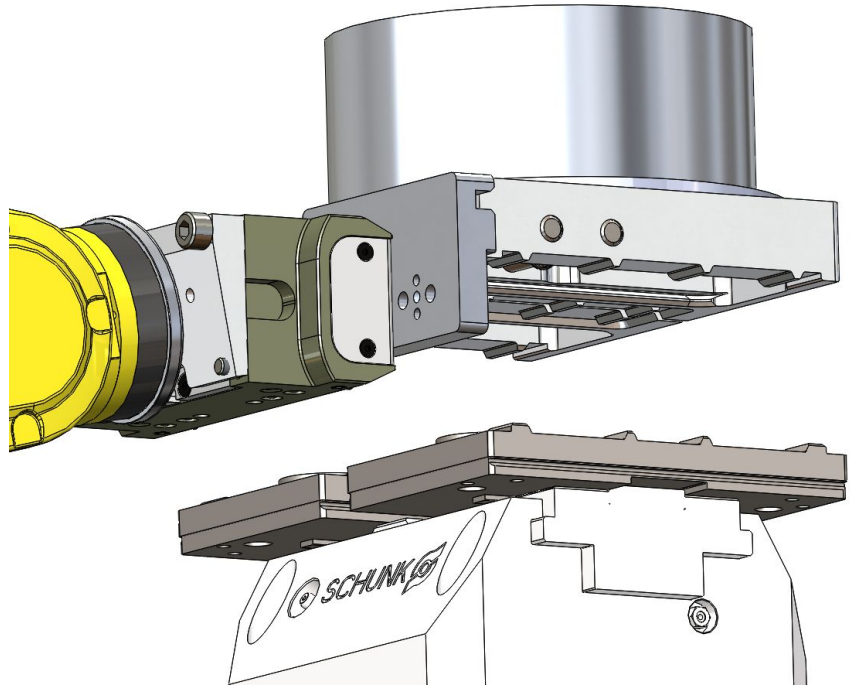
WARNING: MultiGrip components should only be used by trained users, according to all included instructions. Before using MultiGrip components, perform a risk assessment according to local or federal requirements and ensure the MultiGrip products meets all applicable safety requirements.

MultiGrip Overview

Section 2

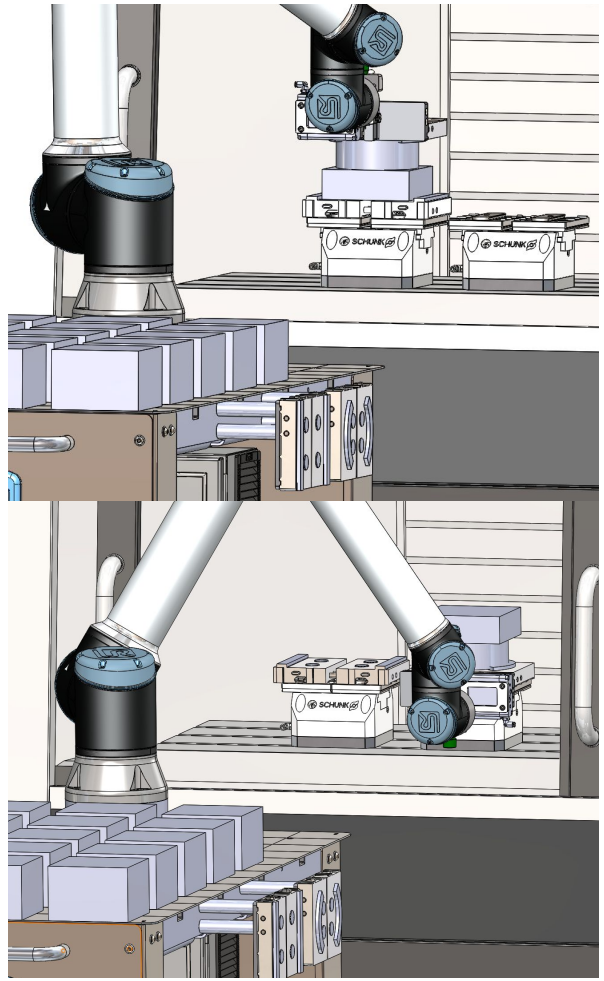
MultiGrip Overview

- MultiGrip is an Automation Workholding System
- MultiGrip components can be used individually or as a system to provide enhanced capabilities
- MultiGrip allows the user to select the components they need today and add additional components as needs change or evolve
- The MultiGrip system supports both hand loading by an operator and automated loading using a robot



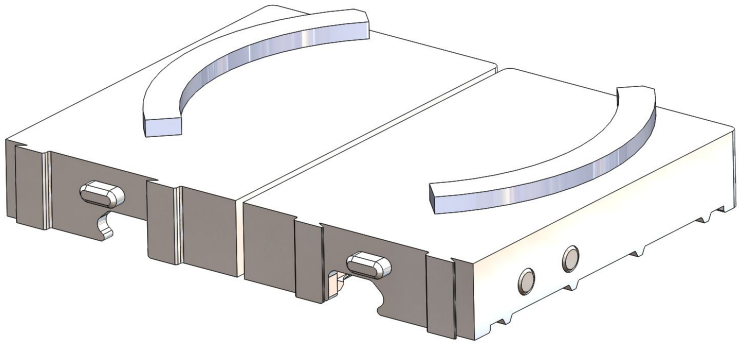
MultiGrip Key Benefits

- MultiGrip is designed from the ground up for CNC machine tending applications
- MultiGrip typically has very low part changeover time - typically less than 5 minutes for an operator to changeover the CNC and robot workholding
- MultiGrip is the only generalized solution for a first operation to second operation transfer in a milling application
- Using MultiGrip allows automation to be adopted faster, with greater reliability and lower costs than other gripper and vise solutions

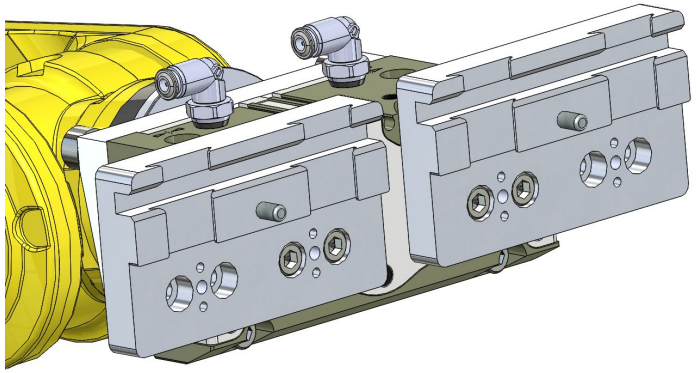


MultiGrip Transfer Operation

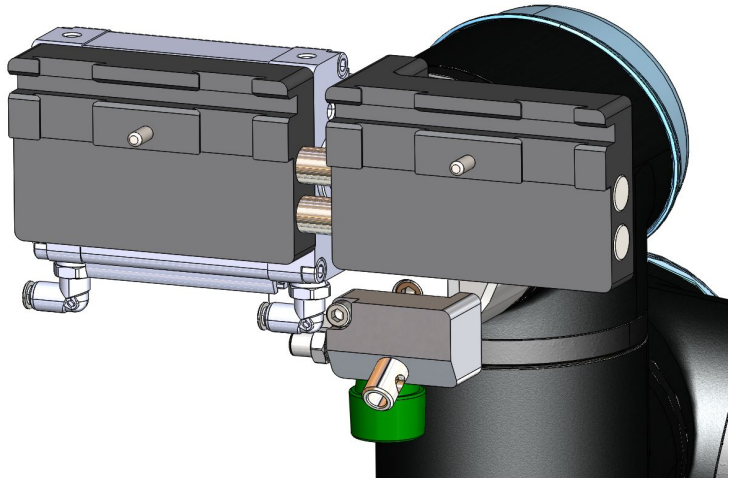
MultiGrip Component Overview



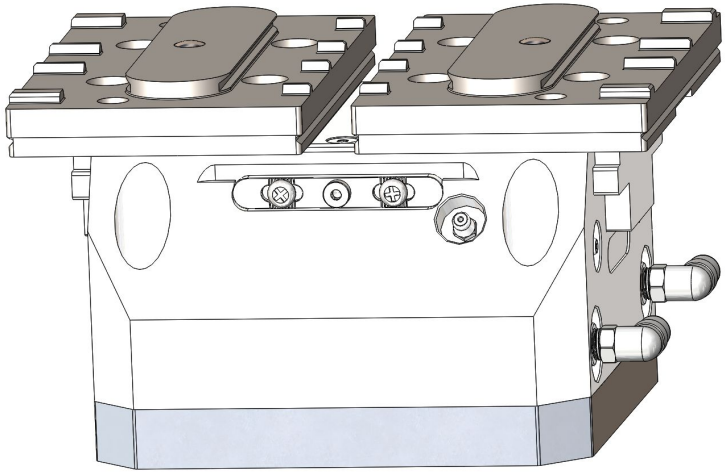
MultiGrip Jaws



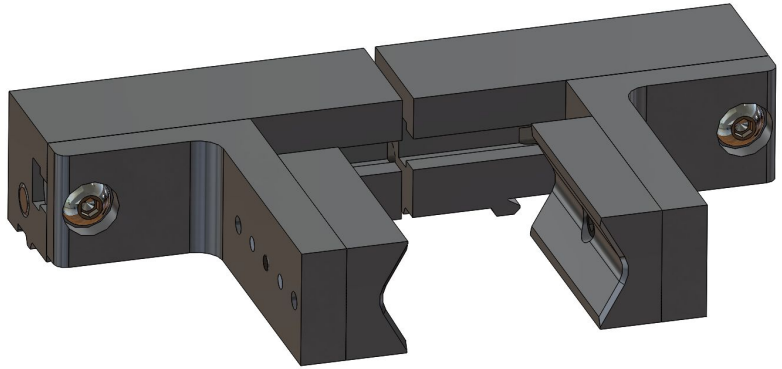
MultiGrip Gripper



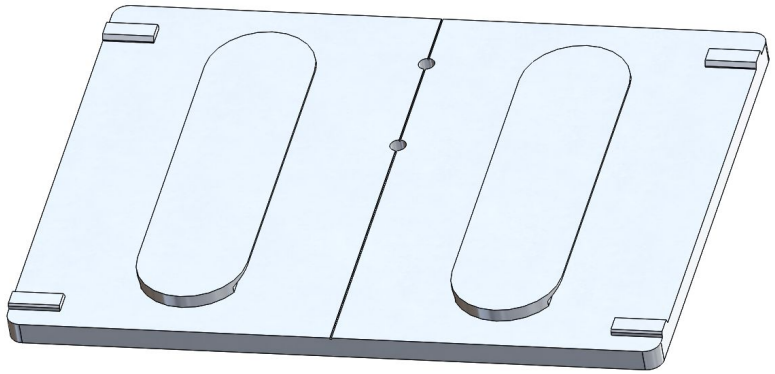
MultiGrip FJ Gripper



MultiGrip Vise



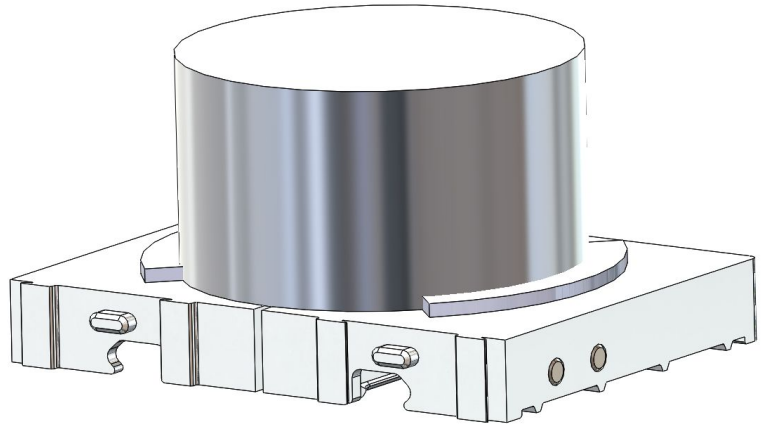
MultiGrip Fingers



MultiGrip Storage Plate

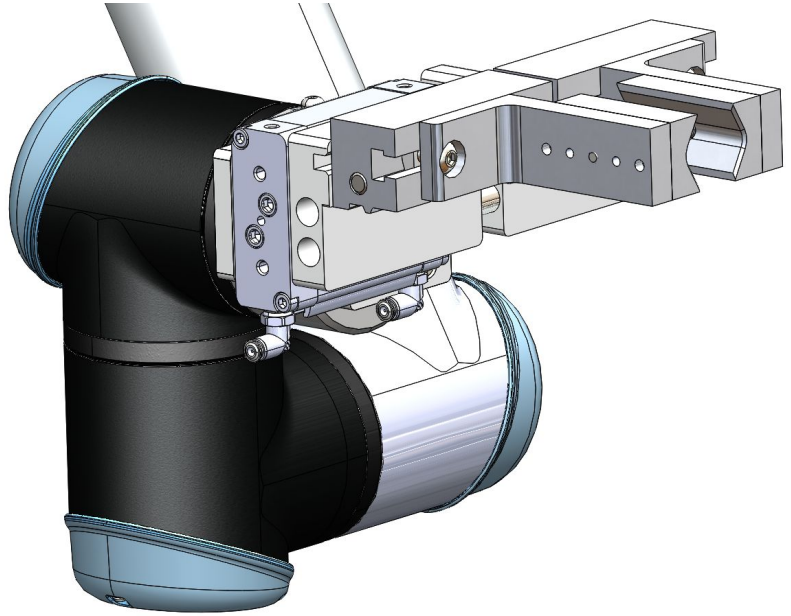
MultiGrip Jaws

- MultiGrip Jaws are the center of the MultiGrip system
- MultiGrip Jaws are a tool that can be picked and placed by a MultiGrip Gripper and held by a MultiGrip Vise or Jaw (MultiGrip) Storage Plate
- Like traditional vise soft jaws, MultiGrip Jaws have a surface that can be machined to hold a part
- Unlike traditional vise soft jaws, MultiGrip Jaws have a vise interface and a robot interface that allows a MultiGrip vise or MultiGrip Gripper to capture, secure and actuate the MultiGrip Jaws
- MultiGrip Jaws can be used to pick, place and transfer parts when held by a MultiGrip Gripper
- MultiGrip Jaws can be used to machine parts when held by a MultiGrip Vise
- When combined with a MultiGrip Gripper and a MultiGrip vise, MultiGrip Jaws allow for simple multi-operation processing



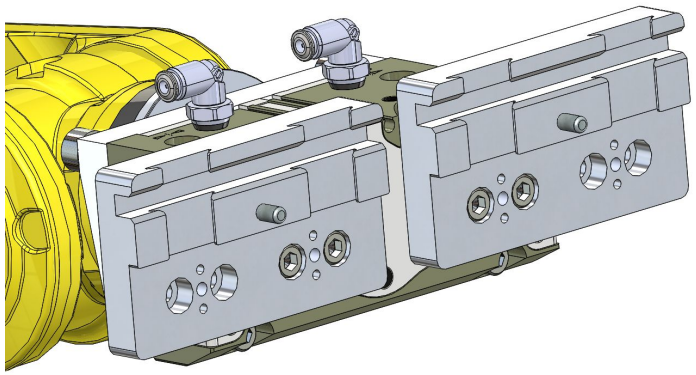
MultiGrip Fingers

- MultiGrip Fingers can be used to pick and place parts like a traditional gripper
- MultiGrip Fingers are most often used in CNC lathe tending applications to load parts into and out of a lathe chuck
- MultiGrip Fingers may also be used to load and unload parts from existing CNC milling fixtures
- MultiGrip Fingers can be stored and retrieved from MultiGrip Storage Plates; they cannot be loaded into a MultiGrip vise



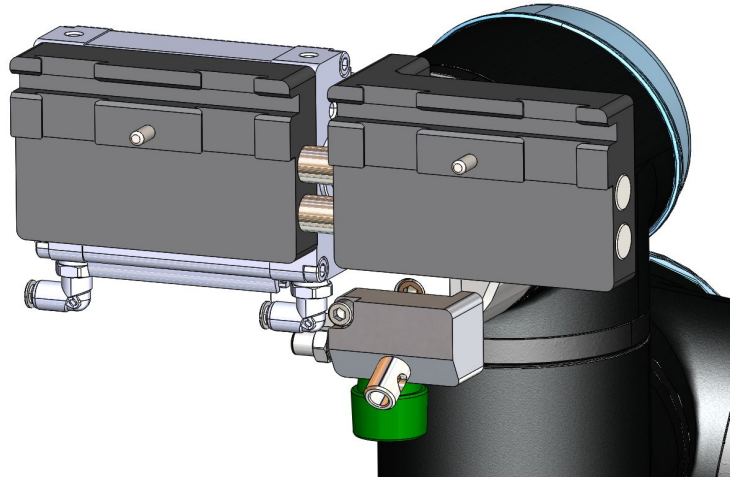
MultiGrip Gripper

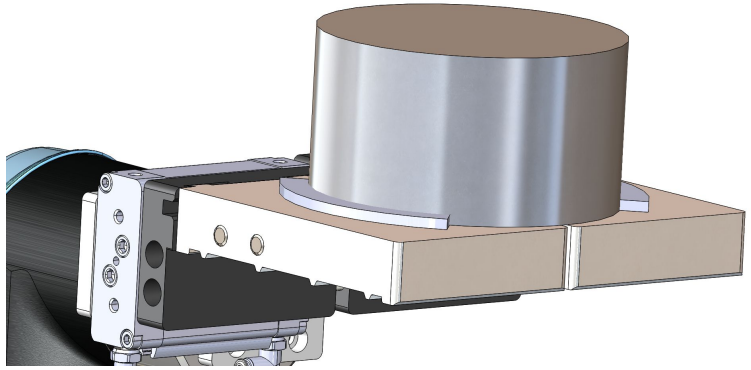
- The standard MultiGrip Gripper is a centering-style pneumatic 2-jaw gripper with a MultiGrip Jaw interface with 20mm of travel and supports OD and ID clamping
- The MultiGrip Jaw interface acts as a tool changer allowing the MultiGrip Gripper to pick, place and actuate MultiGrip Jaws or MultiGrip Fingers
- The MultiGrip Gripper can be used on industrial or collaborative robots
- Centering-style work best when used with a centering vise or centering chuck
- When used with fixed-jaw vises a centering gripper will require a robot that can “float”
- Centering-style grippers are typically heavier than fixed jaw grippers using more of the available robot payload



MultiGrip FJ Gripper

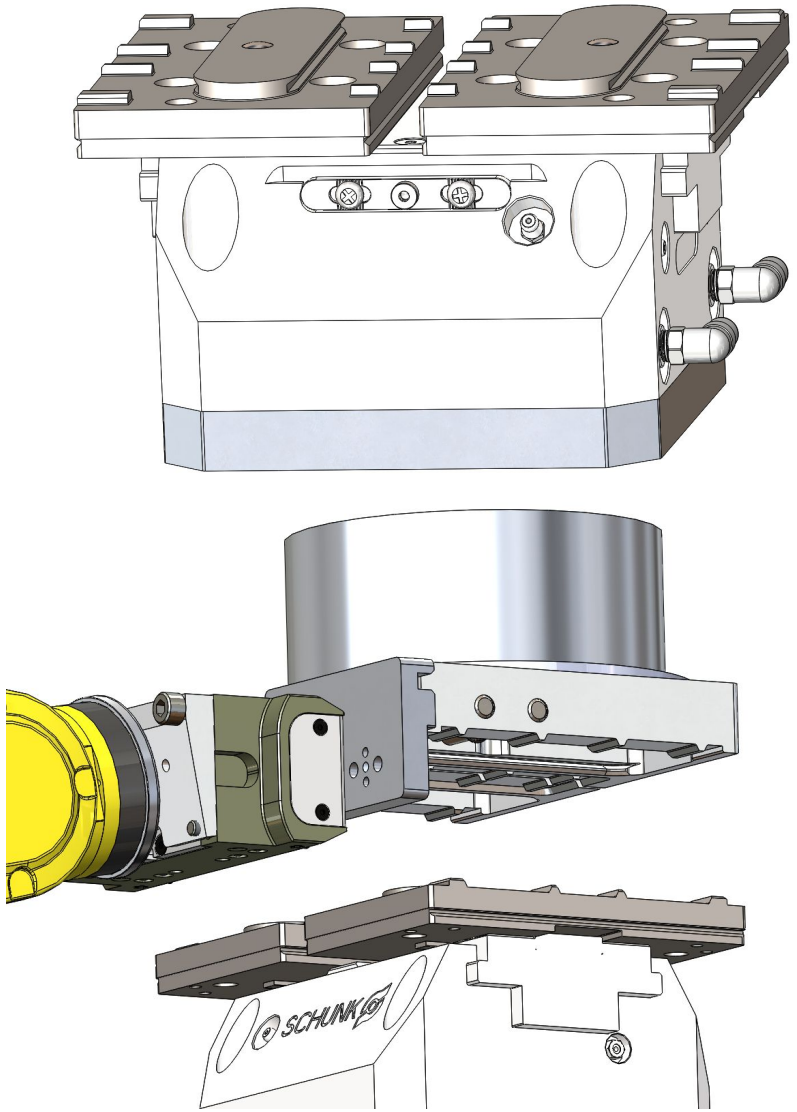
- The MultiGrip FJ Gripper uses one fixed-jaw and one moveable jaw, each with a MultiGrip Jaw interface and 24mm of travel and supports OD and ID clamping
- The MultiGrip Jaw interface acts as a tool changer allowing the MultiGrip FJ Gripper to pick, place and actuate MultiGrip Jaws or MultiGrip Fingers
- The MultiGrip FJ Gripper can be used on industrial or collaborative robots
- Fixed-jaw grippers work best with fixed jaw vises
- When used with centering vises or chucks, a fixed-jaw gripper will require a robot that can “float”
- Fixed-jaw grippers are typically lighter than centering grippers
- Fixed-jaw grippers require and offset approach to the part during pick operations



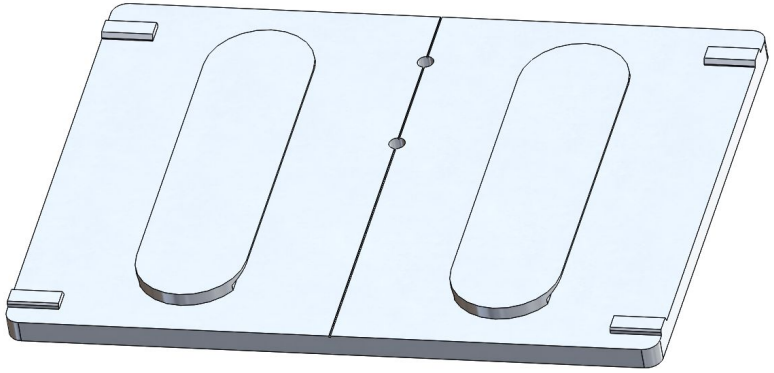


MultiGrip Vise

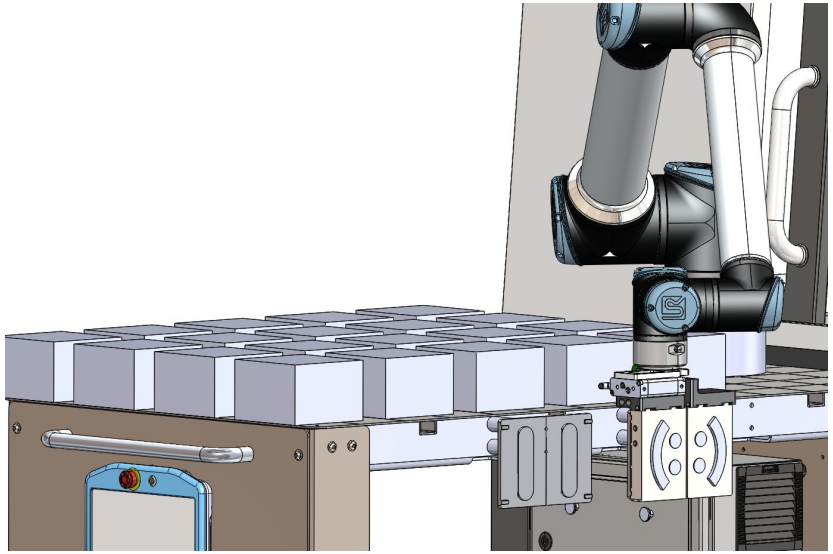
- Centering-style pneumatically actuated vise with 16mm of travel and a MultiGrip interface
- Capable of capturing and securing MultiGrip Jaws and a part without fasteners by simply closing the vise with the jaws in place
- Can be hand-loaded by an operator or automatically loaded by a robot in about 5 seconds
- Repeatability better than 0.0008” total
- Precise, consistent clamping forces through pneumatic control improve quality
- Supports OD and ID clamping



MultiGrip Storage Plates



- Holds MultiGrip Jaws and MultiGrip Fingers for robot retrieval and storage
- Can be mounted horizontally or vertically
- Not designed to hold a part



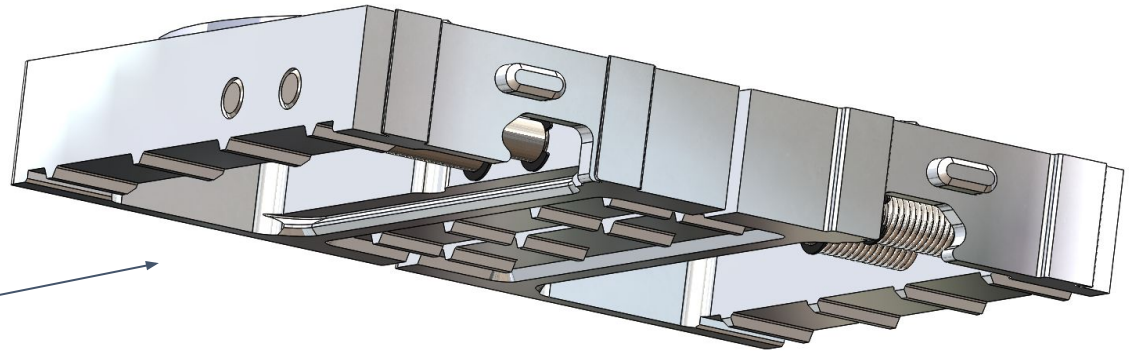
MultiGrip Jaw Details

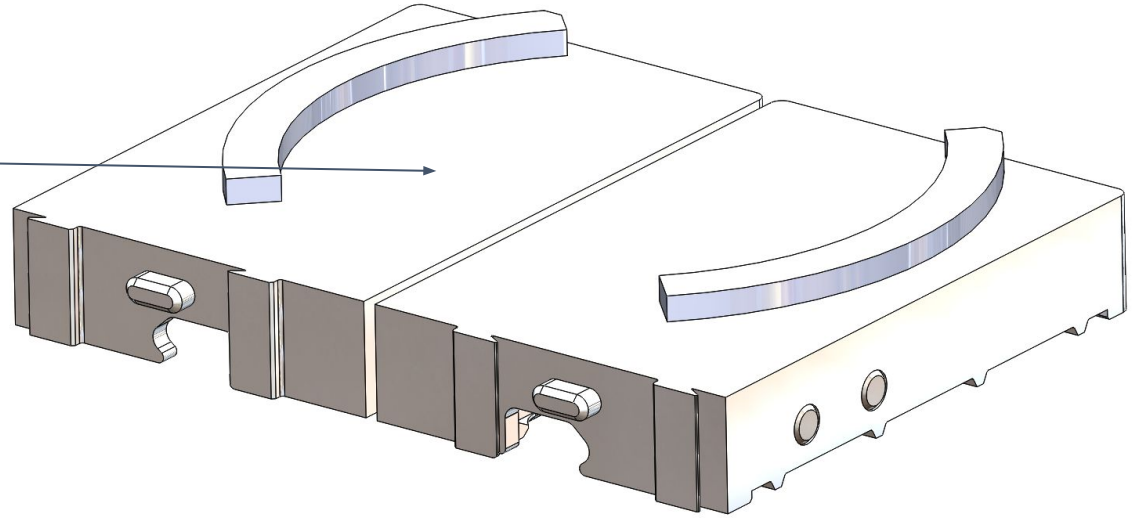
Section 2

MultiGrip Jaw Details

Three interfaces to MultiGrip Jaws:

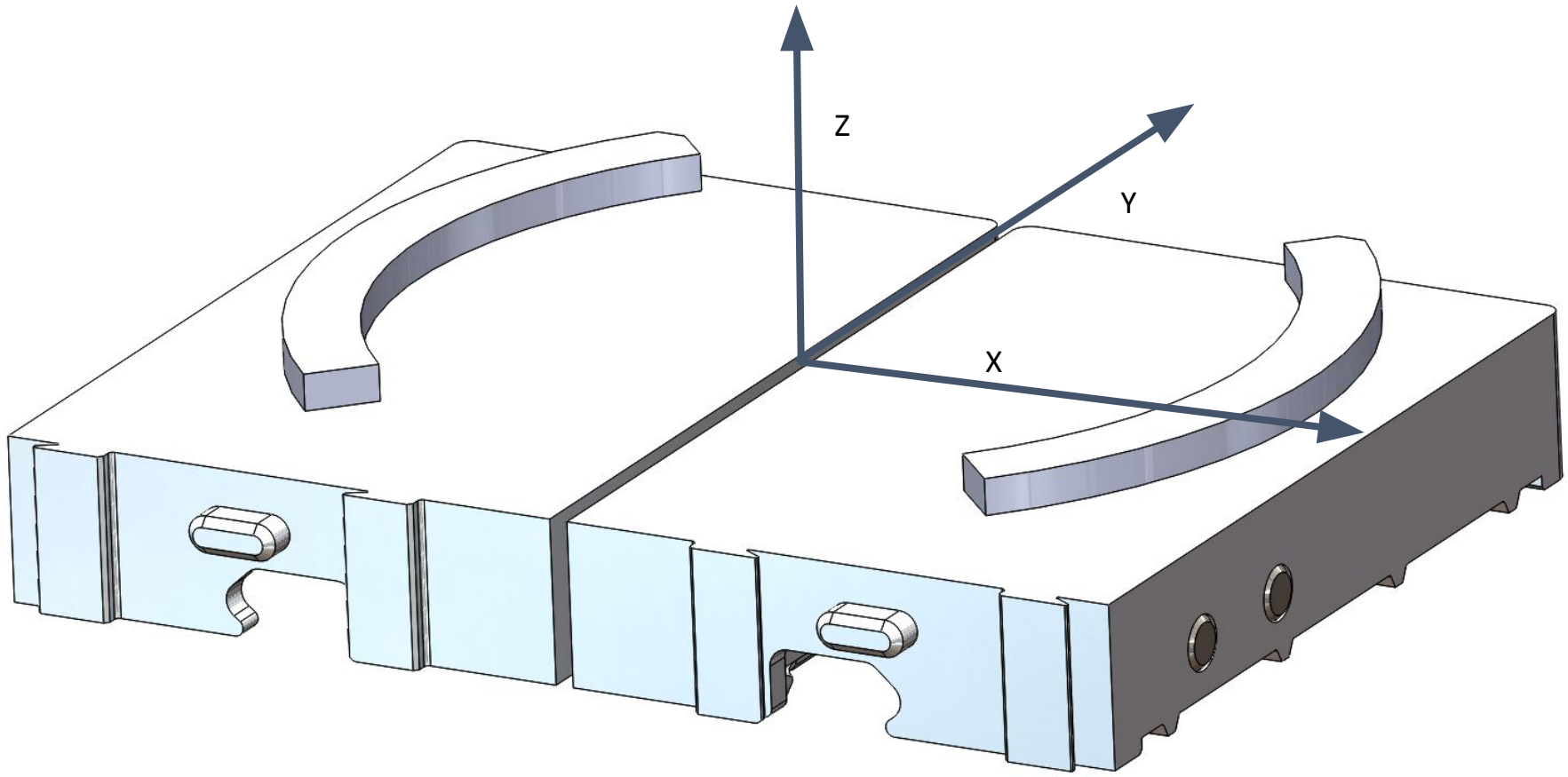
- Vise Interface
- Machinable Part Interface
- Gripper Interface





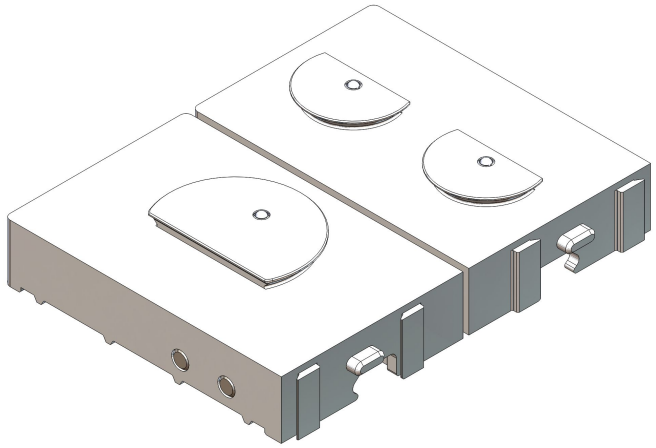
MultiGrip Axis Nomenclature

XYZ axis aligned with typical CNC axis

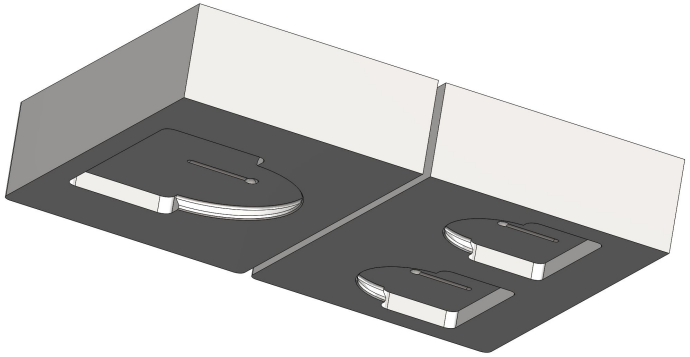


MultiGrip Jaw Types

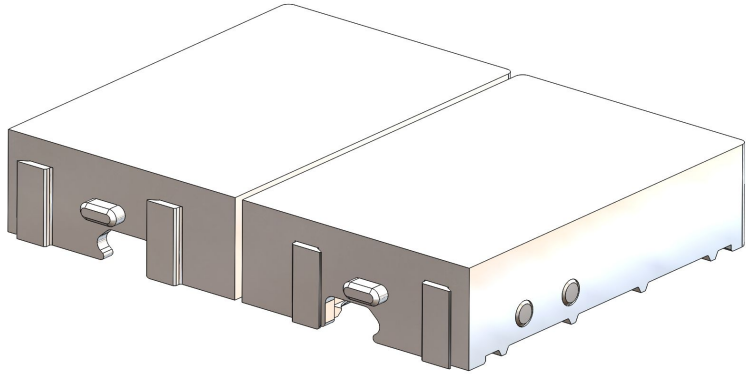
MultiGrip Base Jaws



MultiGrip Top Jaws

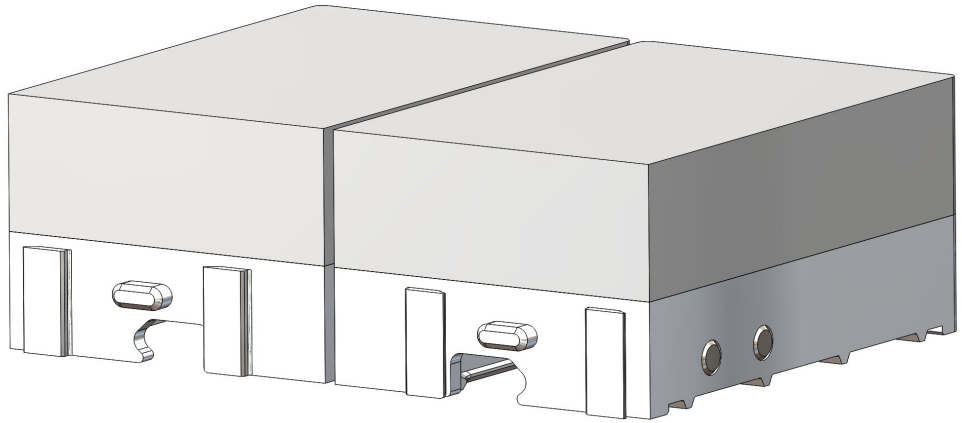


MultiGrip Fixed Jaws



MultiGrip Top Jaws

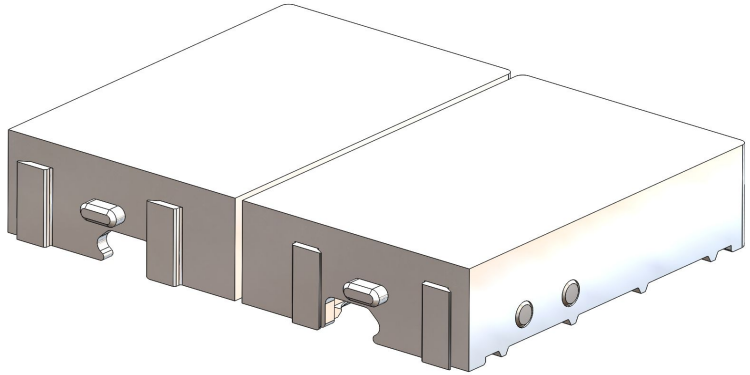
- Part pocket machined into low-cost exchangeable Top Jaws
- MultiGrip Top Jaws snap into place on MultiGrip Base Jaws in seconds
- One fixed Top Jaw, one swivel Top Jaw
- Swivel Top Jaw allows jaws to conform better, increases gripping force on part
- Slightly heavier and slightly taller than MultiGrip Fixed Jaws
- Top Jaws are available in standard and over-sized versions, ID and OD clamping styles, with thickness of 1”, 1.5” and 2”



MultiGrip Top Jaws Mounted on MultiGrip Base Jaws

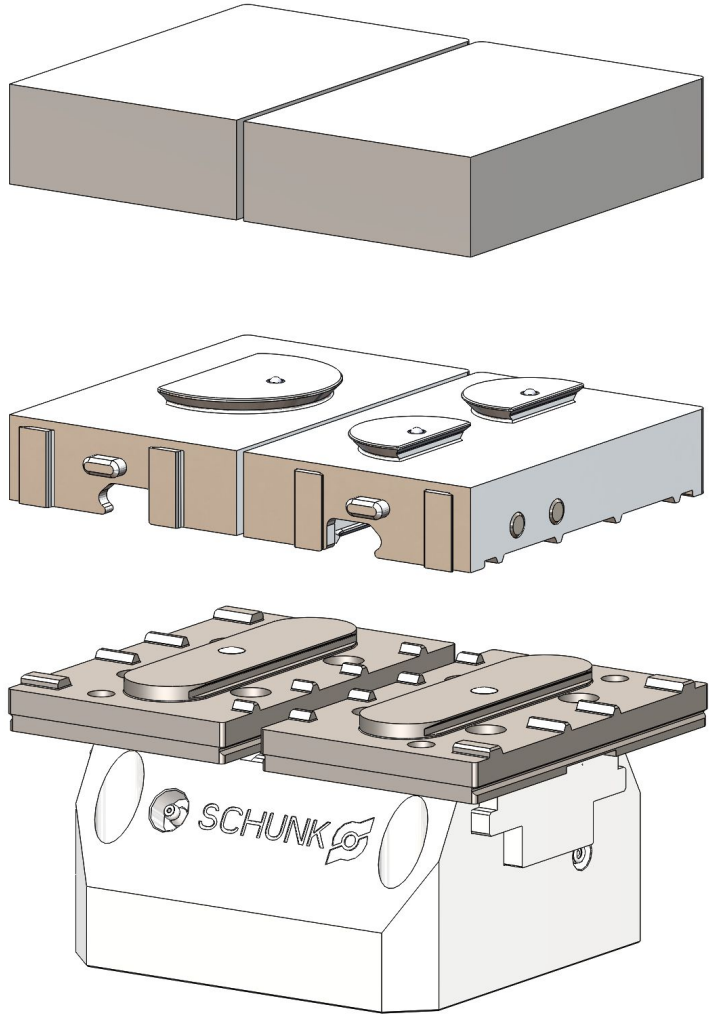
MultiGrip Fixed Jaws

- 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
- Considerations must be made to accomodate jaw deflection during gripper pick of rectangular parts (See section on part picking below for more information)



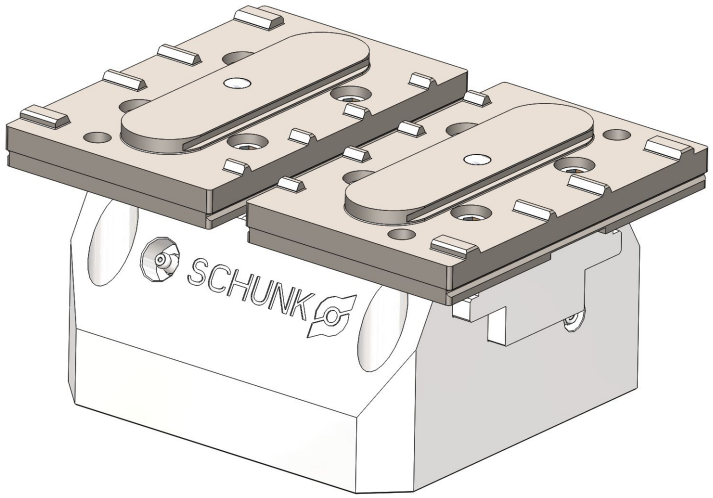
MultiGrip Jaws and Repeatability

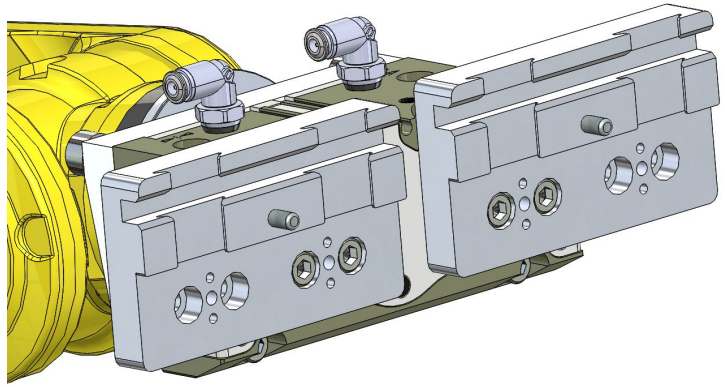
- Best repeatability is achieved when MultiGrip Jaws are paired with the MultiGrip vise they were originally machined on
- For MultiGrip Top Jaws, best repeatability is achieved when the machined Top Jaws are paired with with the MultiGrip Base Jaws and the MultiGrip Vise they were originally machined on
- When Top Jaws are moved onto a different set of MultiGrip Base Jaws or any MultiGrip Jaw is moved to a different vise, confirm location of XYZ pocket
    - Generally, there will be less error in XY and more error in Z when moving MultiGrip Top Jaws from the MultiGrip Base Jaws or MultiGrip Vise they were made on.

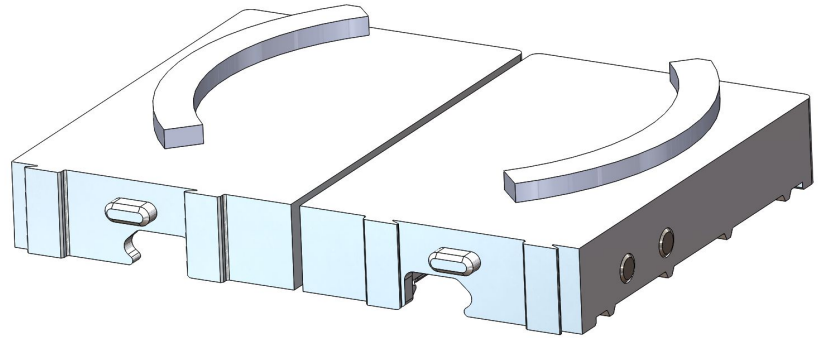


Dry Machining with MultiGrip

- MultiGrip relies on CNC coolant to lubricate the vise interface, the gripper interface and the jaws
- If possible, run coolant after dry machining 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 gripper face







MultiGrip Operations

Section 3

MultiGrip Operations

The following are some of the more common operations that can be performed with the MultiGrip Workholding System:

1. Hand load or unload MultiGrip Jaws or MultiGrip Fingers to a MultiGrip Gripper
2. Hand load or unload MultiGrip Jaws or MultiGrip Fingers to a MultiGrip Storage Plate
3. Hand load or unload MultiGrip Jaws to a MultiGrip Vise
4. Robot load or unload MultiGrip Jaws or MultiGrip Fingers to a MultiGrip Storage Plate
5. Robot pick or place a part using MultiGrip Fingers
6. Robot pick or place a part using MultiGrip Jaws
7. Robot part load or unload of a chuck or vise using MultiGrip Jaws or MultiGrip Fingers
8. Robot MultiGrip Transfer of operation 1 to operation 2 using MultiGrip Jaws and MultiGrip Vises

Hand-Loading a MultiGrip Gripper

1. Open the MultiGrip Gripper
2. Remove pneumatic energy to the MultiGrip Gripper to prevent injury from accidental actuation
3. Align the MultiGrip Jaws or Fingers vertically with the MultiGrip Gripper
4. Squeeze the Jaws or Fingers together so the male dovetails of the Jaws or Fingers align with the dovetail pockets of the Gripper
5. Slowly release the Jaws or Fingers so the male dovetails engage the female dovetails
6. To remove MultiGrip Jaws or Fingers from the MultiGrip Gripper, with the MultiGrip Gripper open, squeeze the Jaws or Fingers together until they can be pulled away from the Gripper

Hand-Loading a MultiGrip Storage Plate

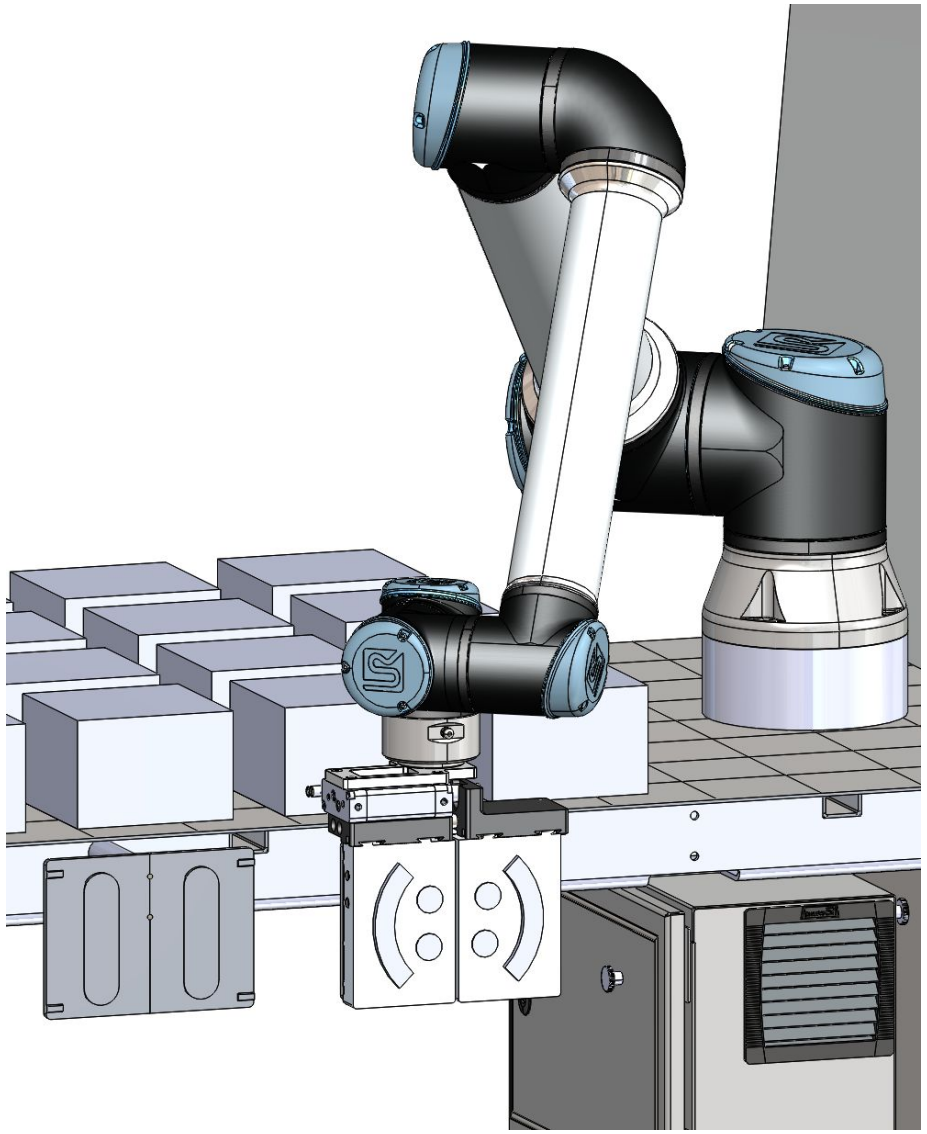
1. Align the MultiGrip Jaws or Fingers with the MultiGrip Storage Plate
2. Squeeze the Jaws or Fingers together so the dovetails of the Jaws or Fingers fit inside the the dovetails of the MultiGrip Storage Plate
3. Slowly release the Jaws or Fingers so the dovetails of the Jaws or Fingers engage the dovetails of the MultiGrip Storage Plate
4. To remove MultiGrip Jaws or Fingers from the MultiGrip Gripper, squeeze the Jaws or Fingers together until they can be pulled away from the MultiGrip Storage Plate

Hand-Loading a MultiGrip Vise

1. Open the MultiGrip Vise
2. Remove pneumatic energy to the MultiGrip Vise to prevent injury from accidental actuation
3. Align the MultiGrip Jaws so they are centered over the MultiGrip Vise
4. Squeeze the Jaws together so the dovetails of the Jaws fit inside of the dovetails of the MultiGrip Vise
5. Slowly release the Jaws so the dovetails engage each other
6. To remove MultiGrip Jaws from the MultiGrip Vise, with the MultiGrip Vise open, squeeze the Jaws together and lift the Jaws away from the MultiGrip Vise

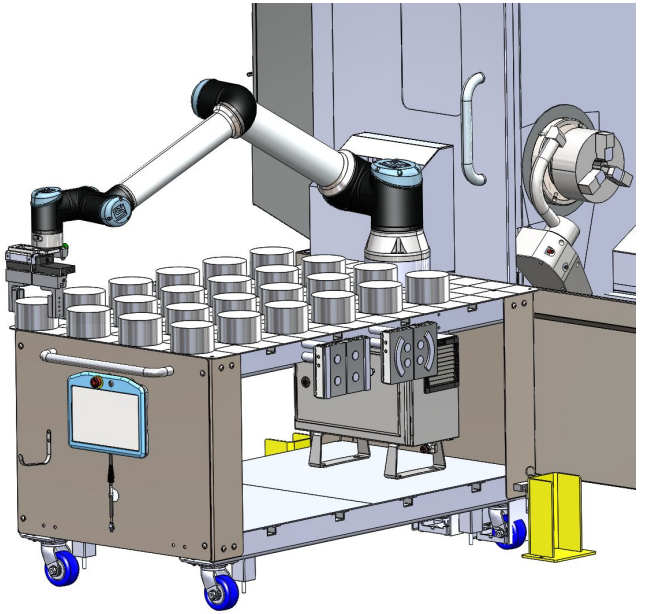
Robot Loading/Unloading MultiGrip Storage Plates

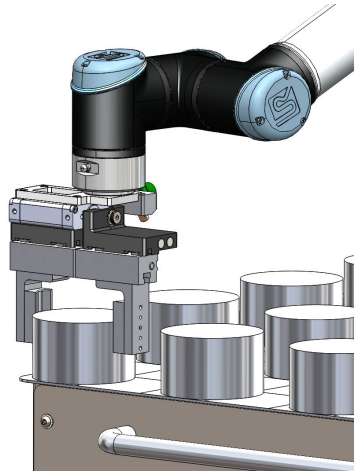
- Both MultiGrip Jaws and MultiGrip Fingers can be loaded to or unloaded from MultiGrip Storage Plates using a robot
- Most automation applications will begin with the necessary MultiGrip Jaws or MultiGrip fingers mounted on MultiGrip Storage Plates
- During automation processing, the robot will pick and place MultiGrip Jaws or Fingers as needed for processing
- MultiGrip Storage Plates cannot be used to hold parts that are being held by either MultiGrip Jaws or Fingers



Robot Pick/Place using MultiGrip Fingers

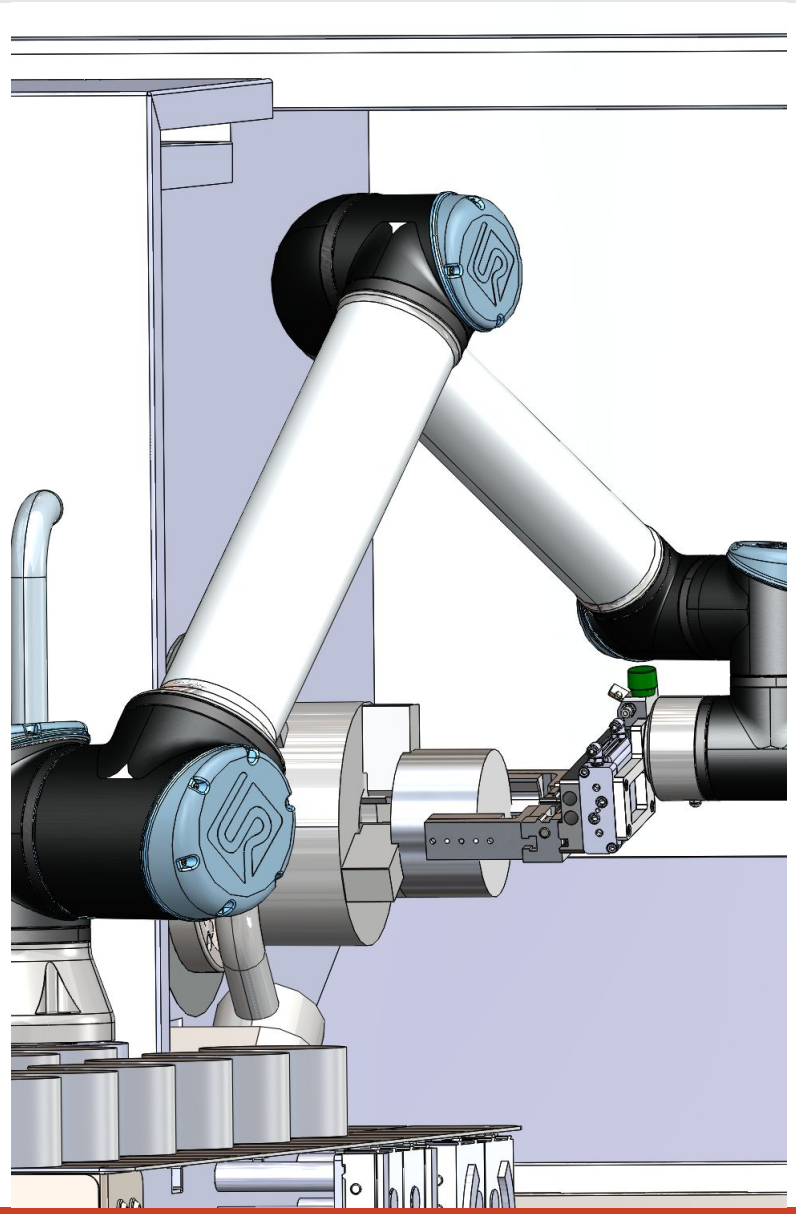
- MultiGrip Fingers can be used by a robot to pick or place parts between an infeed and a CNC
- Unlike MultiGrip Jaws, MultiGrip Fingers cannot be loaded into a MultiGrip Vise
- MultiGrip Fingers are typically used in lathe applications or applications that use existing automatic fixtures
- MultiGrip Fingers are adjustable for part width or diameter and include exchangeable finger tips to handle almost any size or shape of part
- For more information on MultiGrip Fingers, see the MultiGrip Finger Manual





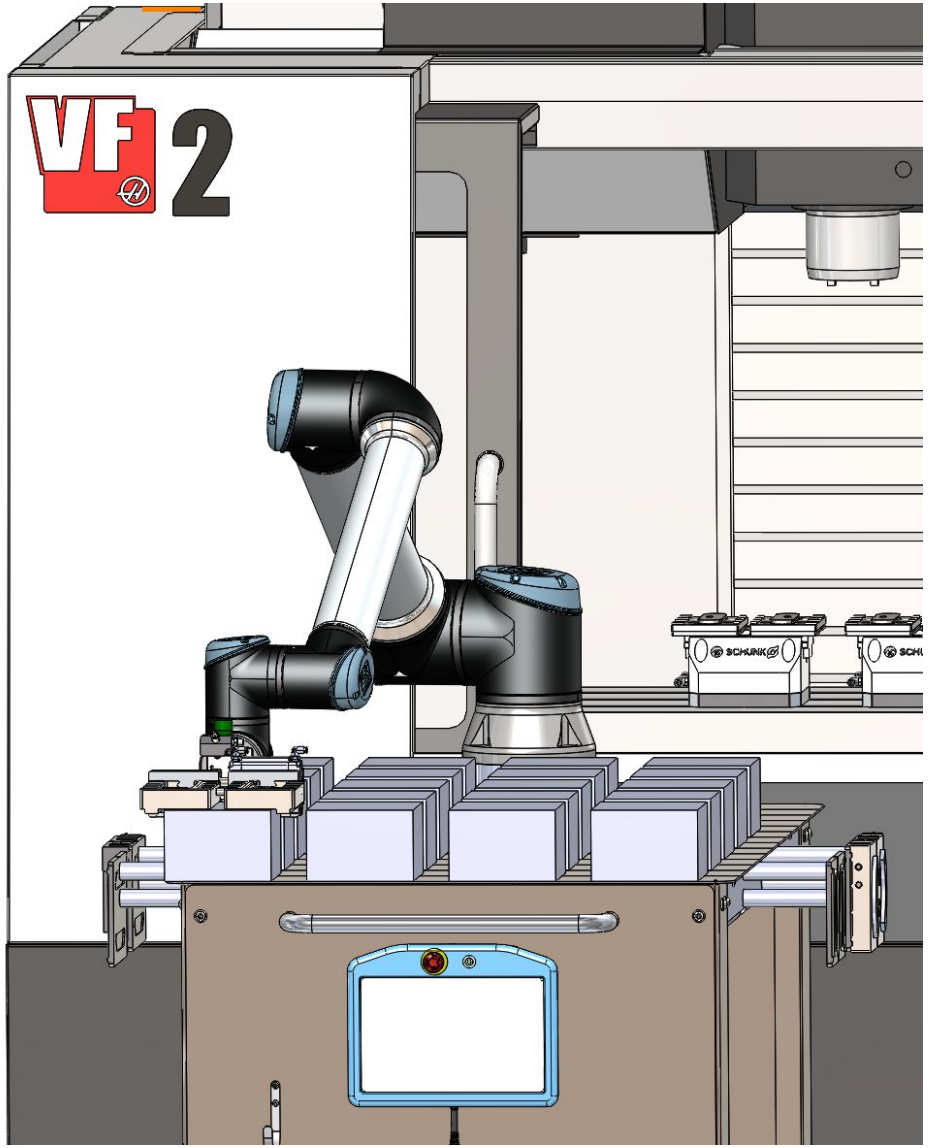
Robot Part Load using MultiGrip Fingers

- MultiGrip Fingers can be used by a robot to pick or place a part into or out of an existing CNC chuck or vise
- MultiGrip Fingers can also used to load a MultiGrip Vise, typically when the first operation MultiGrip jaws are not well suited to picking the parts from the infeed
- For more information on MultiGrip Fingers, see the MultiGrip Finger Manual



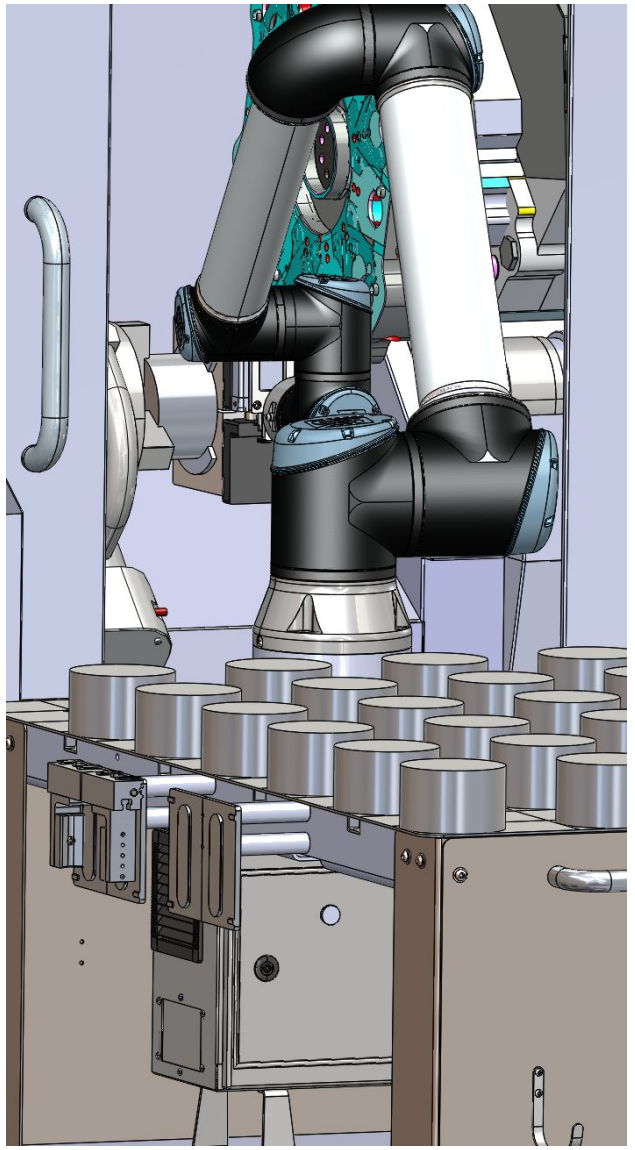
Robot Pick/Place using MultiGrip Jaws

- MultiGrip Jaws can be used by a robot to pick or place parts between an infeed and a CNC
- MultiGrip Jaws are typically used in milling applications with one or more MultiGrip Vises



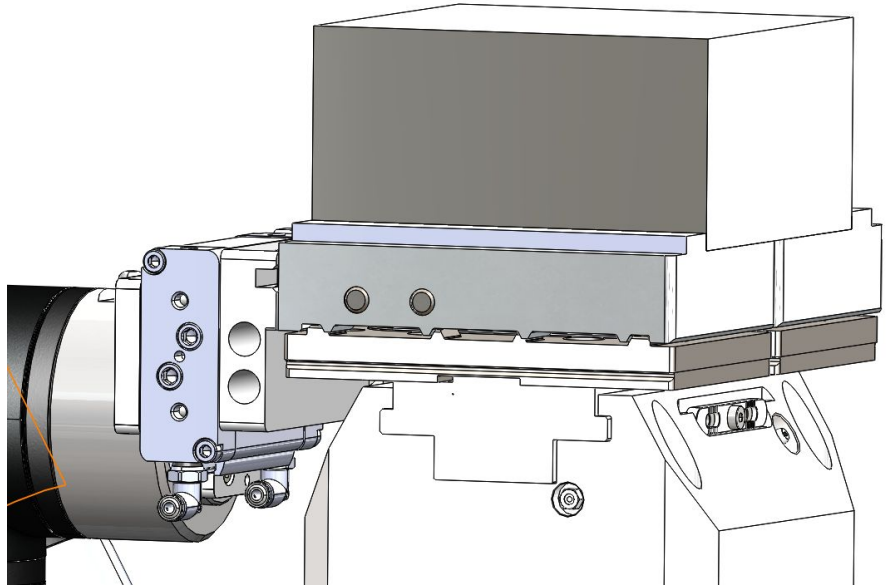
Robot Part Load using MultiGrip Jaws

- MultiGrip Jaws can be used by a robot to pick or place a part into or out of an existing CNC chuck or vise
- Although MultiGrip Fingers are typically used for Part Load into a CNC Chuck or Vise, MultiGrip Jaws can also serve this purpose



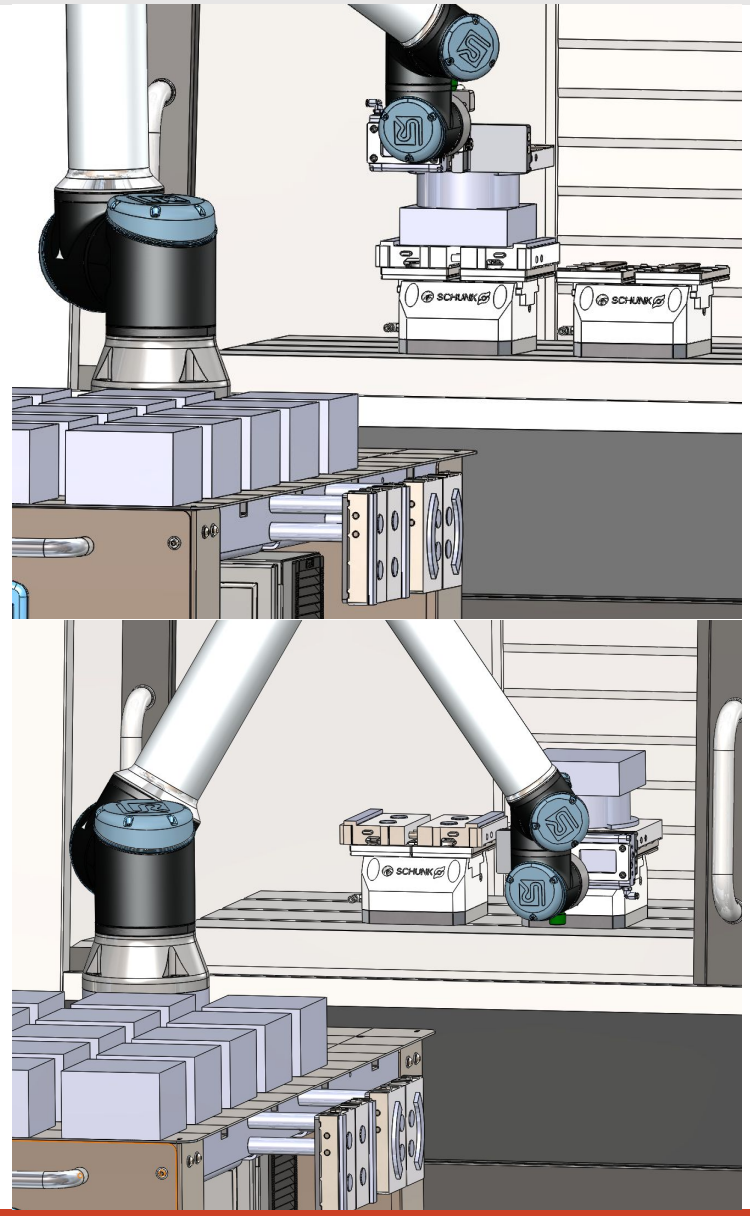
Robot Vise Load using MultiGrip Jaws

- Most robot milling applications will use MultiGrip Jaws to pick a part from infeed and load the part and Jaws into a MultiGrip Vise (setting up a MultiGrip Transfer Operation, see next page)
- A robot can also load empty MultiGrip Jaws into a MultiGrip Vise
    - Some applications will use MultiGrip Jaws that are pre-loaded and remain on a MultiGrip Vise and use MultiGrip Fingers to load parts into the MultiGrip Jaws on the Vise
- MultiGrip Jaws can be unloaded from a MultiGrip Vise using a robot either with or without a part being held



MultiGrip Transfer Operation

- One of the unique capabilities of MultiGrip is the ability to perform a transfer operation from a first operation to a second operation without a re-grip step
- After the first operation is complete, the robot inverts the second operation MultiGrip Jaws over the part and picks the part out of the vise
- The robot then loads the second operation MultiGrip Jaws into the next vise to resume processing



Picking Parts with MultiGrip

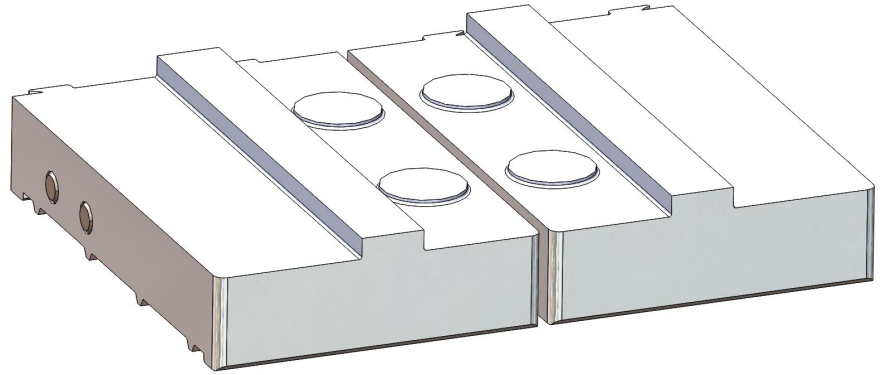
Section 4

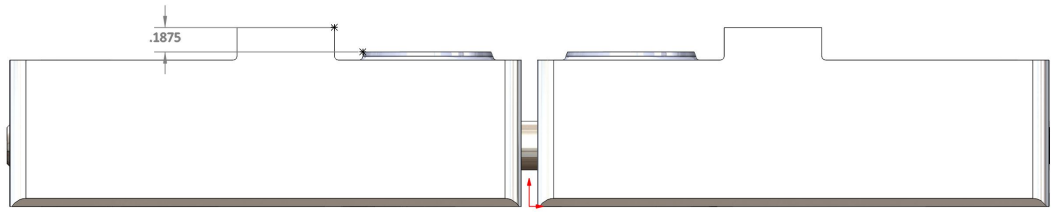
Part Weight and Gripping Force

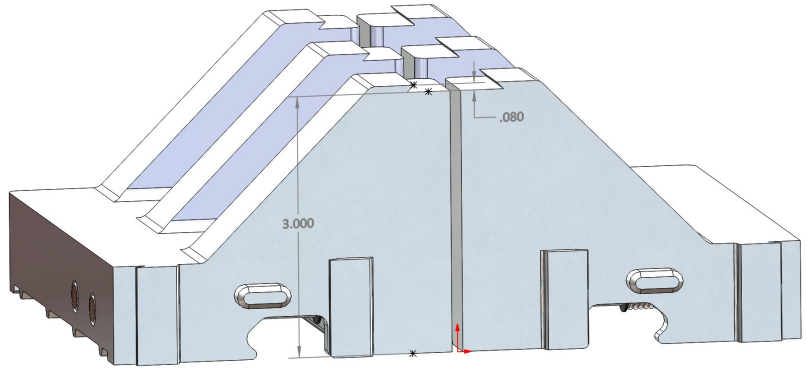
- The maximum weight a gripper can hold is typically limited by the closing clamping force and the friction between the gripper and the part
- A simple formula for maximum part weight is MaxWeight = (GrippingForce x CoefficientOfFriction) / SafetyFactor
- When picking a metal part with metal gripper with coolant as a lubricant, a typical coefficient of friction is 0.2
- A typical safety factor is 2 for robots with slow acceleration and up to 4 for robots with high acceleration
- Example: MaxWeight = (100lbs x 0.2) / 2 = 10lbs
- Consult your MultiGrip Gripper or MultiGrip FJ Gripper manual for gripping force and gripper weight

MultiGrip Jaw Design Best Practices for Picking Parts

- Keep jaw weight to a minimum by cutting away unnecessary material from within the pocket and outside the pocket
- Support the part in Z using short pads
  - Reduces chance of light parts sticking to jaws
  - Lifts part corner out of radius between floor and wall of jaw pocket
- For jaws that will pick raw material from an infeed area, recommended minimum pocket depth of 0.1875” (5mm)
- For jaws that will pick a machined surface on a part from a vise, recommended minimum pocket depth of 0.080” (2mm)
- Recommended maximum overall height of jaws (bottom of jaws to bottom of part Z support) of 3” (75mm)

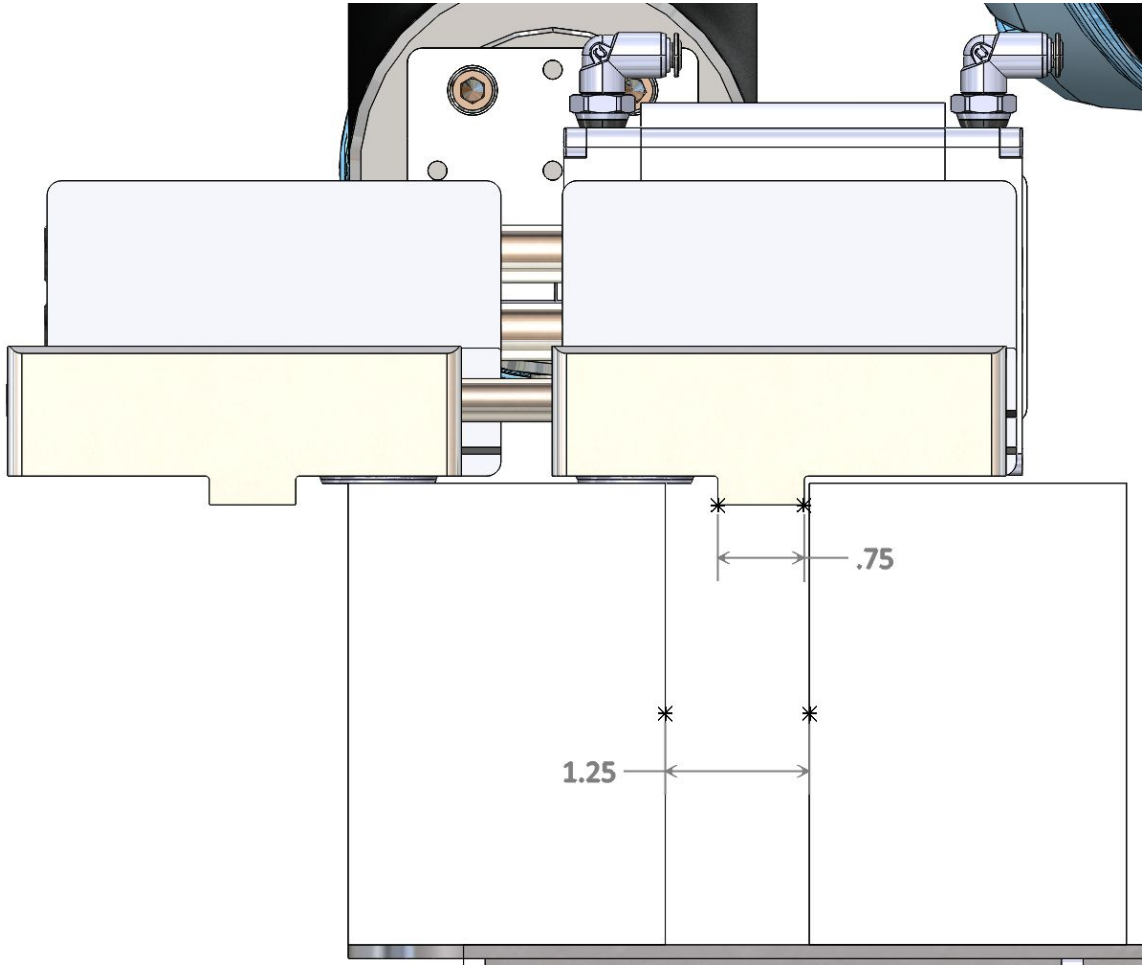






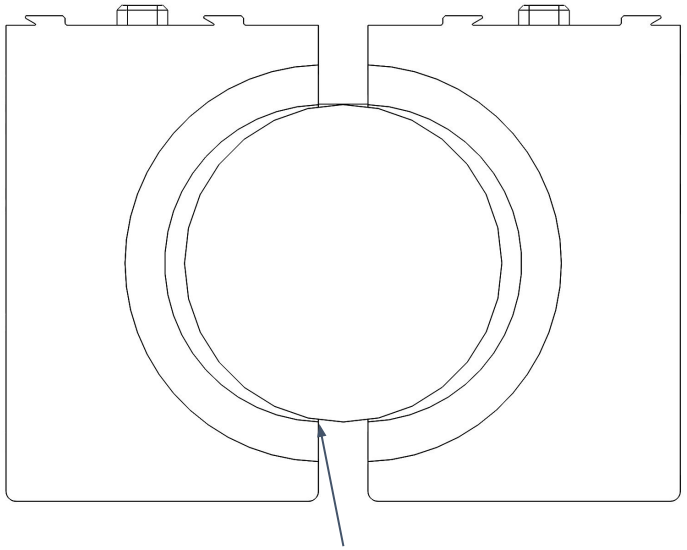
MultiGrip Jaw Pocket Wall Width and Part Spacing

- Jaw pocket wall width should be kept to 0.75” (19mm) or less
- With a jaw pocket wall width of 0.75”, the minimum spacing between parts is 1.25” (32mm)

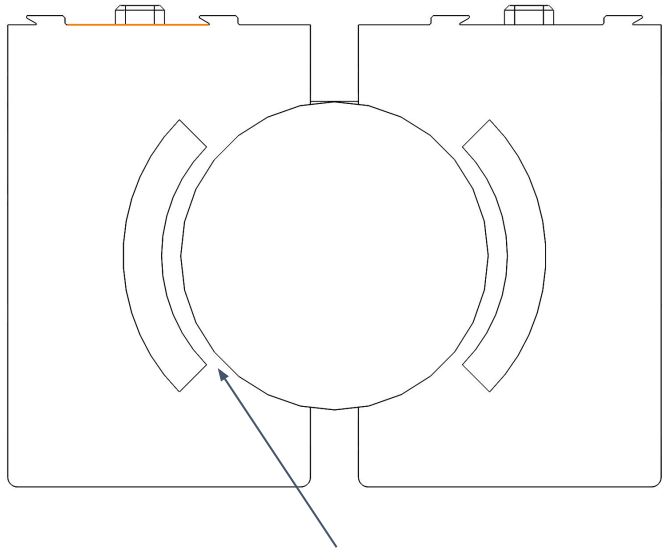


Clearance Between Jaw Pocket and Part During Pick

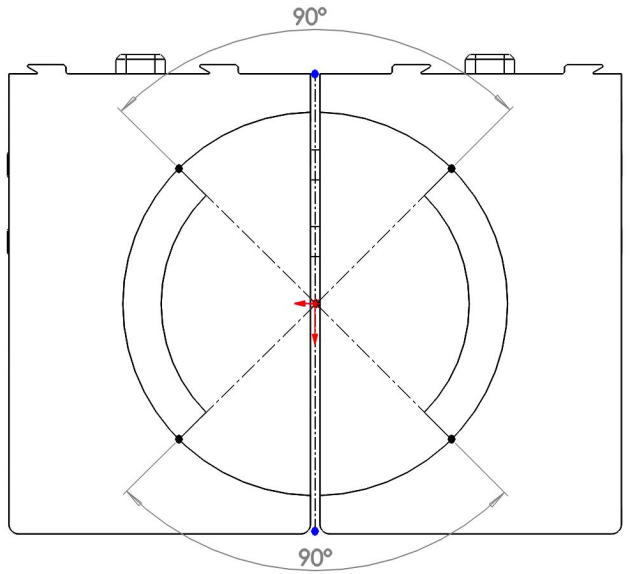
- Design part pocket so that when the jaws are fully open, there is adequate clearance between the the part and pocket
- Avoid pocket features that approach parallelism with the X plane of the jaws
- For round parts we recommend a 90 degree clearance cut along both sides of Y axis



Not enough clearance between part and jaws during pick



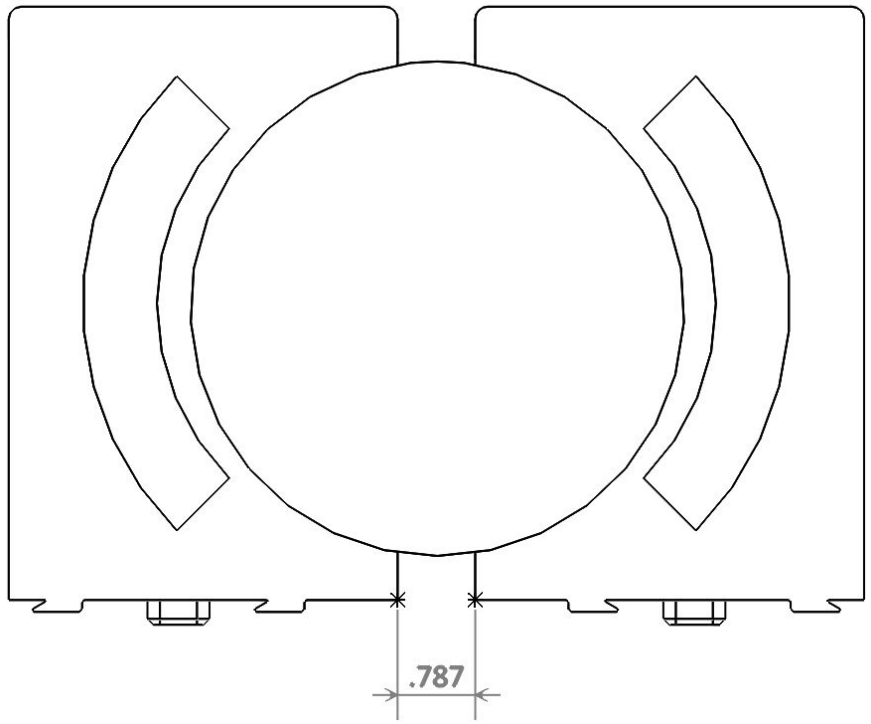
Enough clearance between part and jaws during pick

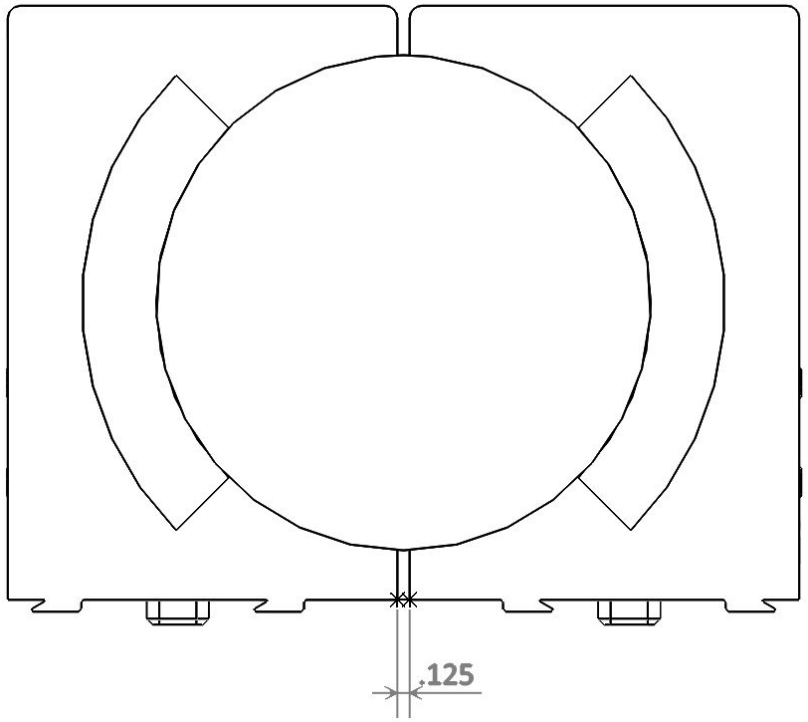


90 degree cut along Y axis for part clearance

Clearance Between Jaw Pocket and Part During Pick

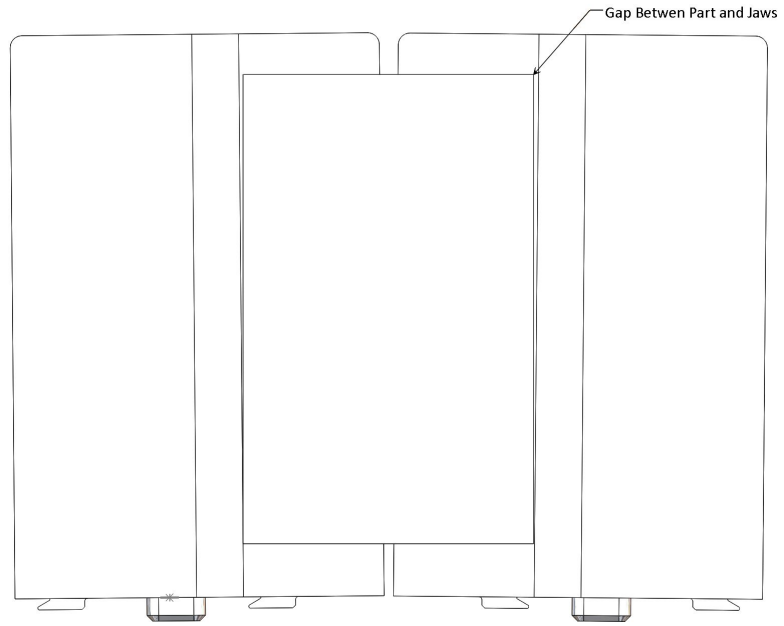
- Consider the jaw stroke and nominal clamp positions during pick
- OD jaws max opening = 0.787” (20mm), nominal clamp = 0.125”
- ID jaws min closing = 0.0”, nominal clamp = 0.394” (10mm)





MultiGrip Fixed Jaw Deflection During Pick

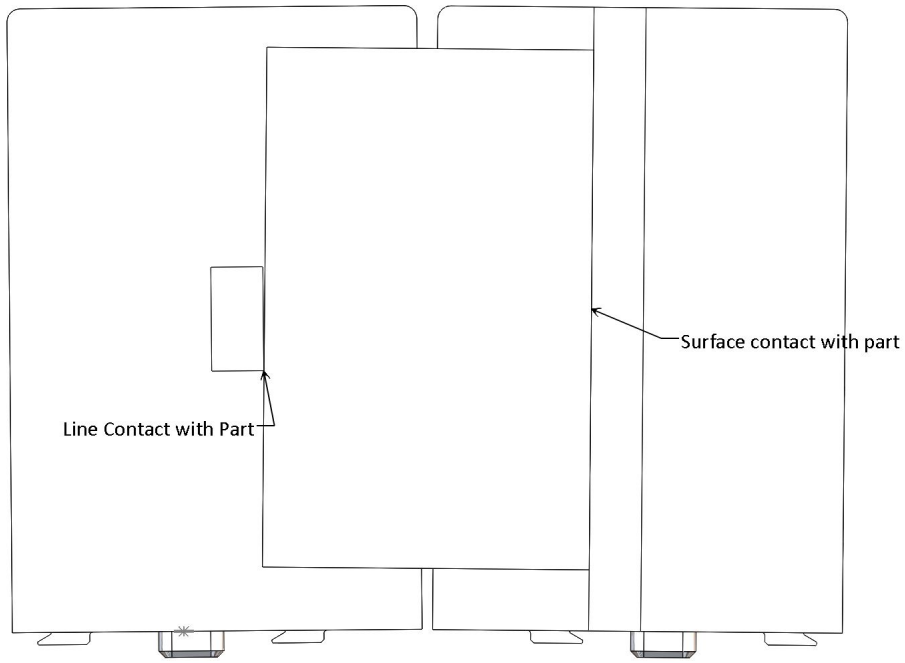
- The MultiGrip Gripper allows the MultiGrip Jaws to deflect a small amount during part grip*
- MultiGrip Top Jaws include a fixed jaw and a swivel jaw; the swivel jaw is designed to rotate to ensure full part contact with the part during during part pick as the jaw deflects
- MultiGrip Fixed Jaws do 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

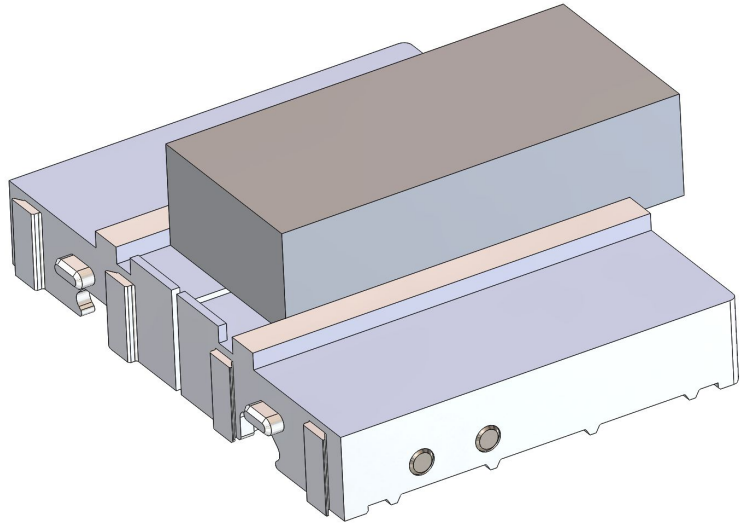
MultiGrip Fixed Jaw Deflection During Pick

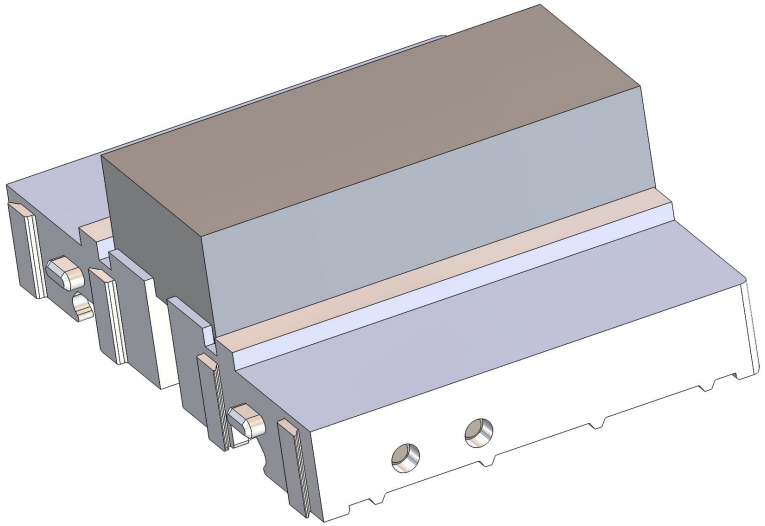
- When using MultiGrip Fixed Jaws with rectangular parts, triangulation of the jaw pocket will typically provide good results during pick
- Triangulation of the of the jaw pocket is not necessary for round parts using MultiGrip Fixed Jaws



Locating Rectangular Part in Y Using Gripper Settle

- 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 6” 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
- Position the robot so the jaws are tilted along the X axis then open and close the gripper
  - Recommend at least 250 milliseconds of open time



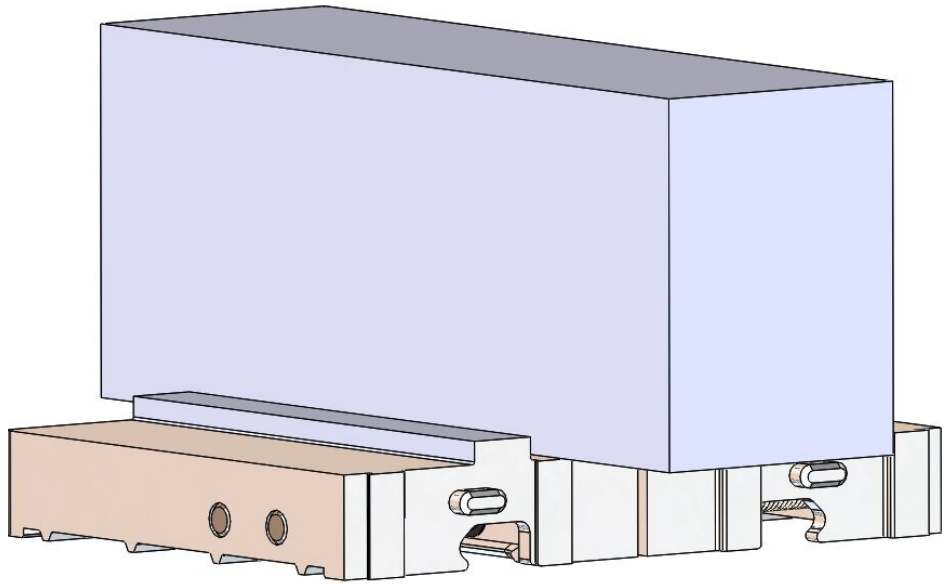


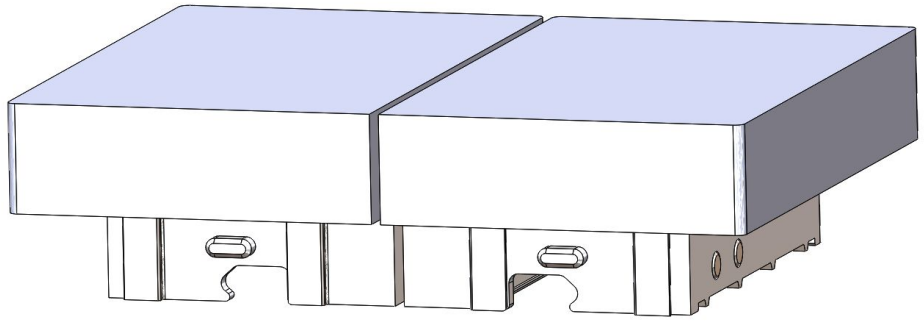
Locating Rectangular Parts in Y Using Gripper Settle

- Generally, parts less than 0.8” wide cannot be settled using Gripper Settle with standard MultiGrip Top Jaws or MultiGrip Fixed Jaws unless additional considerations are made
- When the gripper opens, the gap between the jaws is 0.787” (20mm) and the part will fall into the gap
- If required, a “bridge” can be built between the jaws to prevent the part from falling into the gap during a settle operation
- See section 5.3 for information on vise settling

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 have it’s Y datum set during a vise settle operation (see section 5)
- Alternatively, oversized Top Plates be used to better support larger parts



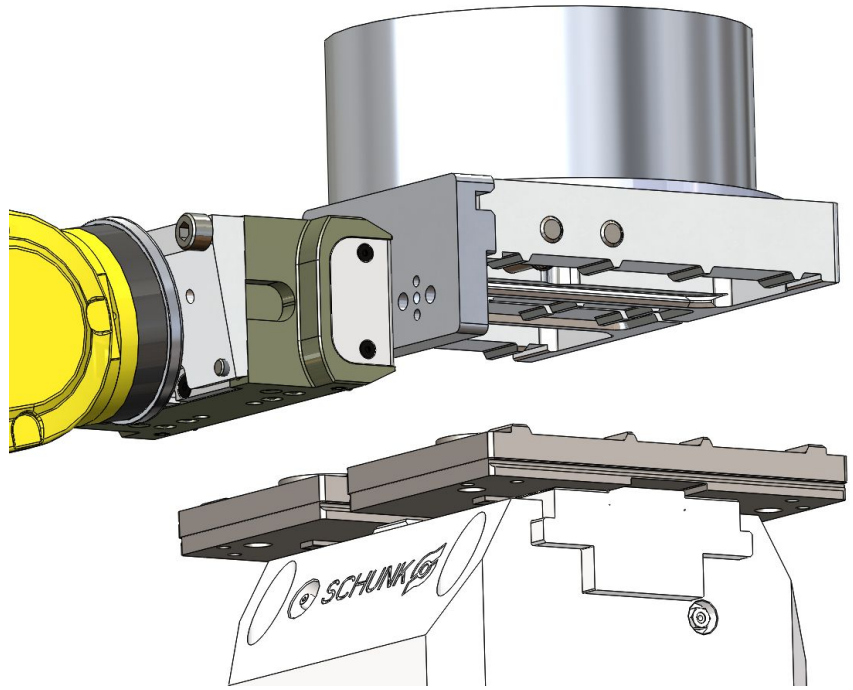


Machining Parts with MultiGrip

Section 5

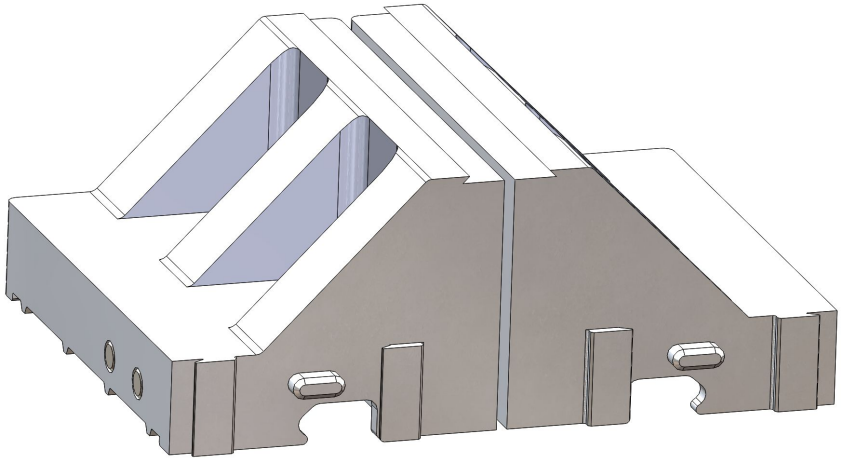
MultiGrip Jaw Design for Machining

- 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



MultiGrip Jaw Pocket Design for Machining

- For most efficient processing, use the same MultiGrip Jaws for picking and machining
- Note that jaw design requirements for part picking may be incompatible with jaw design requirements for machining:
  - Pocket depth for picking is too deep for machining sides of part
  - Jaw design for machining is too heavy for robot to pick jaws and part
  - Jaw pocket wall width is too wide for picking parts from infeed
- If jaws are not compatible for picking and machining, load MultiGrip Jaws onto MultiGrip Vise and part load material using MultiGrip Fingers or MultiGrip Jaws optimized for picking



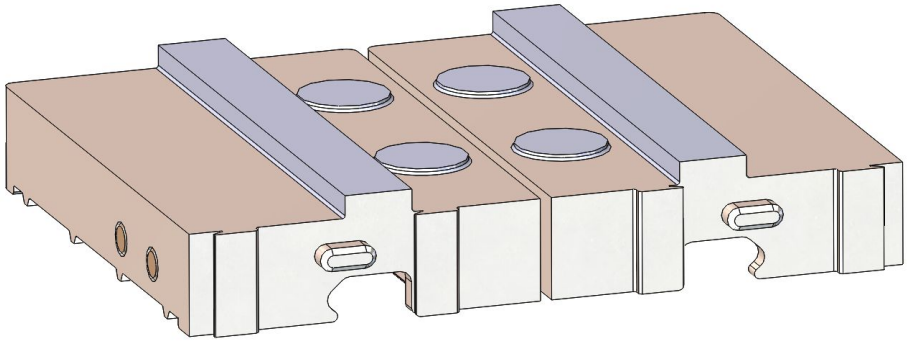
MultiGrip Jaws Optimized for 5-axis Machining

Part Settling

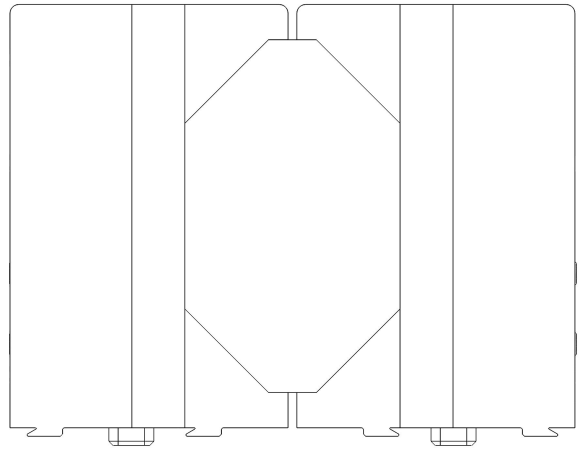
- Part settling is the term used to accurately position a part in the MultiGrip jaw pocket for CNC processing
- Accuracy and repeatability of the workpiece in the workholding can be affected by the part geometry, part weight and the jaw pocket design
- Almost any part can be accurately positioned in 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

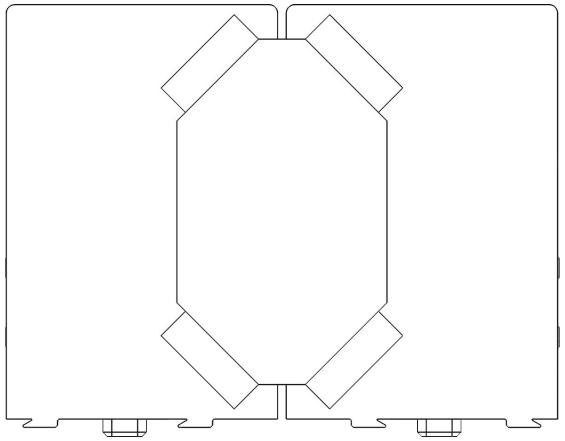
- To prevent part lift in Z during clamp, avoid a sharp corner between the Z locating surface of the jaws and the jaw pocket wall
  - Pads on the floor of the jaw pocket are a simple solution
- When possible, use the shape of the part to locate the part in Y and if required, rotation about Z



Pads on floor of Jaw Pocket



Jaw Pocket does not locate part in Y



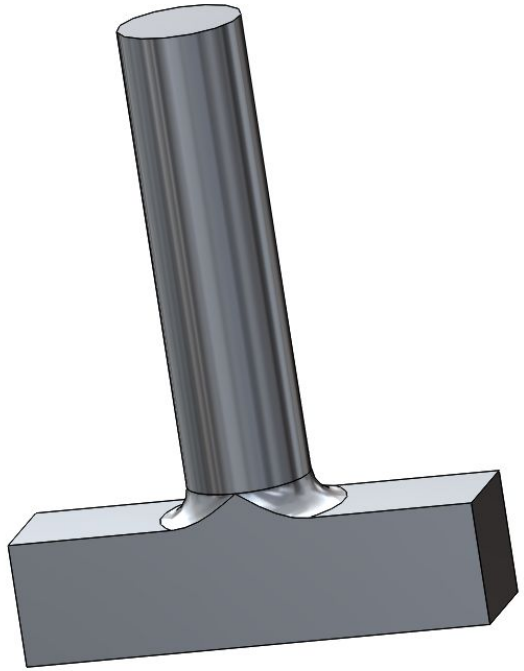
Jaw Pocket locates part in Y

Part Settling in Z using Gravity

- Opening and then closing the vise after loading is simple, fast and will settle most parts in Z accurately
  - Vise settle is more accurate at settling parts in Z than the gripper settle operation
  - Vise settle cannot be used on parts less than 0.5” wide, the part will fall between the jaws when the vise opens
  - For parts less than 0.5” wide, use a a Z support to bridge the gap between the jaws when the part opens or use a Z-push tool and vise pressure control commands with a CNC settle program (see following pages)

CNC Part Settling

- Parts can be more precisely positioned using a CNC settling program and Y and/or Z Settle Tools
- Depending on how your automation system is configured, automatic vise control will come from the CNC or the Robot
- To position a rectangular part in Y, do the following:
  - Position the Y Settle tool just in front of or behind the part and along the part's Y axis
  - Open the vise
  - Feed the Y settle tool into the part, making sure the part should always be moved some distance
  - Close the vise
  - Move the Y settle tool away from the part first in Y and then in Z



Y Settle Tool

CNC Part Settling

- To precisely settling a part in Z can be done by reducing vise pressure (if equipped with programmable pressure) or opening and closing the vise with the Z settle tool in place
- Reducing pressure to the vise:
  - Reduce vise pressure to a minimum value
  - Position and feed the Z settle tool into the part, using the compliance of the elastomer to apply pressure
  - If necessary, feed into multiple locations to ensure part is completely seated
- Opening and close the vise:
  - Position and feed the Z settle tool into the part, using the compliance of the elastomer to apply pressure
  - Open the vise, wait a small amount of time, close the vise
  - Retract the Z settle tool

Z Settle Tool

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 and improve the positional accuracy of the part or MultiGrip jaws in the CNC machine
  - Offset position due to thermal changes
  - Validate MultiGrip Jaws and/or part is located correctly in the jaws before machining
- Refer to the CNC spindle probe documentation for more information
- Remember that spindle probes require regular calibration to maintain high accuracy

Using a CNC Probe to Verify 2nd Operation Load

- When making a two operation part from uneven raw material, when the part is loaded into the second operation, a CNC spindle probe will not be able to detect if the part was settled properly in the second operation jaws
  - This is because only rough raw material is available to probe
- Although rare in a proven automation process, a chip or other problem could prevent the part settling in the jaws properly resulting in a bad run of parts
- To validate the part is properly settled in the second operation jaws, there are two different strategies that can be employed:
  - Pre-operation
  - Cutting a probing feature using a key cutter in the first operation
- In both instances, the objective is to provide a machined surface the CNC spindle probe can reach to verify the part is settled after the second operation load

Using a CNC Probe to Verify 2nd Operation Load

- Pre-operation
  - Turns a two operation part into a three operation part
  - Start by loading the part into a MultiGrip vise using a “pre-operation” set of MultiGrip Jaws and cut a flat Z surface and an XY datum into the part
  - Perform a MultiGrip transfer to the first operation MultiGrip Jaws, the pre-operation surface will be facing the Z surface of the jaws and the raw material will be facing the CNC spindle
  - After the first part machining operation is complete, perform a MultiGrip transfer to the second operation jaws
  - The flat Z surface and XY datum cut in the pre-operation are now available for the CNC spindle probe to verify

Using a CNC Probe to Verify 2nd Operation Load

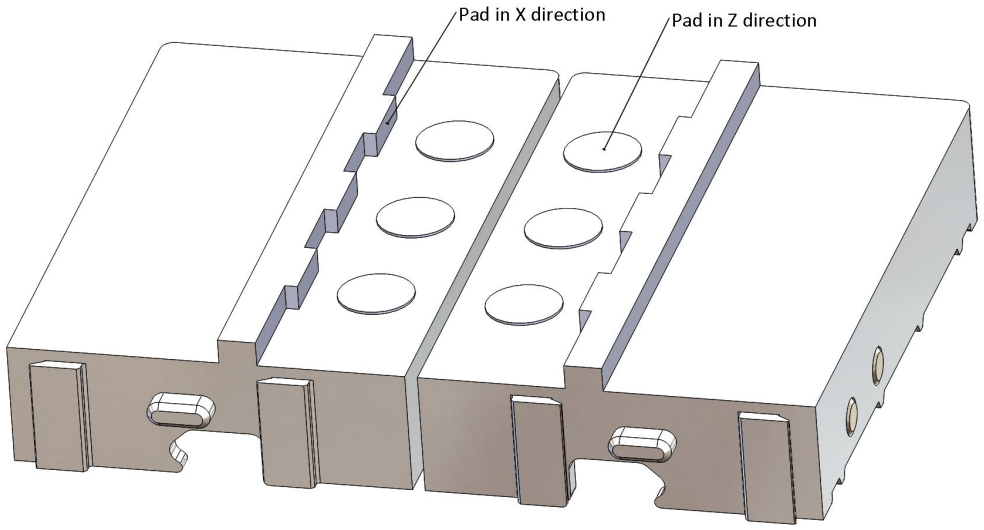
- Cutting a probing feature in the first operation
  - The CNC, part and/or MultiGrip Jaw geometry must support access to the bottom of the part
  - If the part has a large through-hole, a key cutter may be used to cut a Z surface and a hole or an XY edge on the bottom of the part
  - On a 5-axis machine, if the bottom of the part can be reached with an endmill, cut a flat Z surface and an XY datum
  - After the MultiGrip transfer to the second operation is complete, use a CNC spindle probe to validate the location of the flat Z surface and the XY datum

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 vertical surfaces of the jaw pocket 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

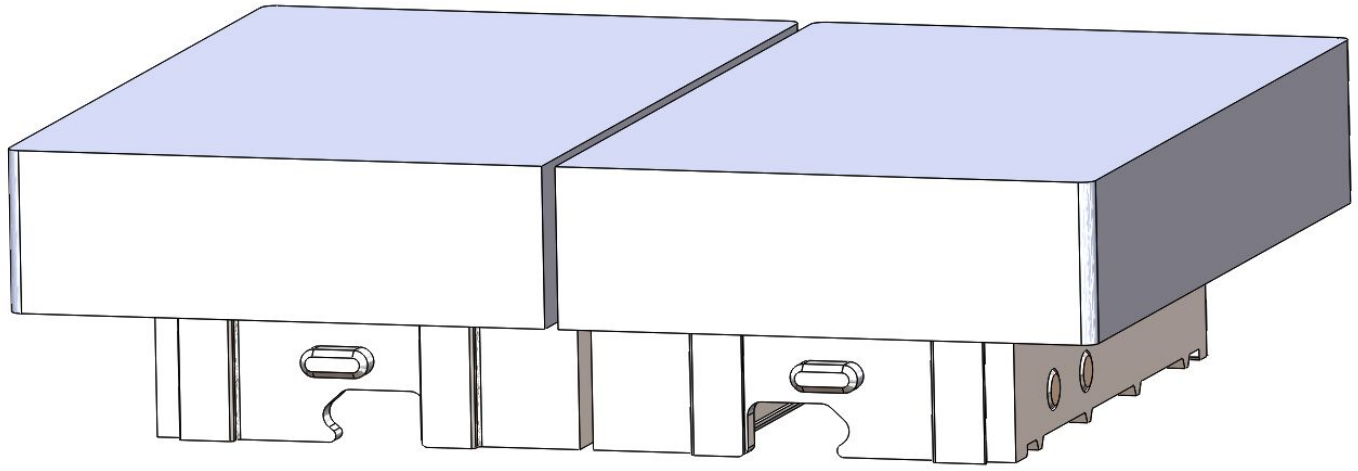
Part Release During Place to Outfeed

- 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

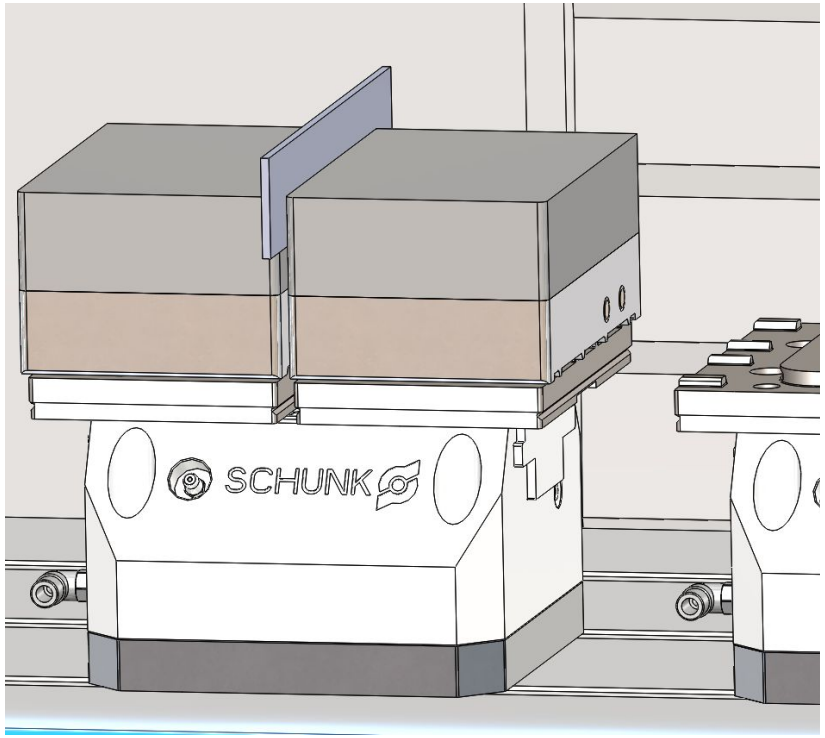


Repeatability

- 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
  - In this configuration, repeatability of the workholding is generally better than 0.0008” total
- 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 too
  - 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

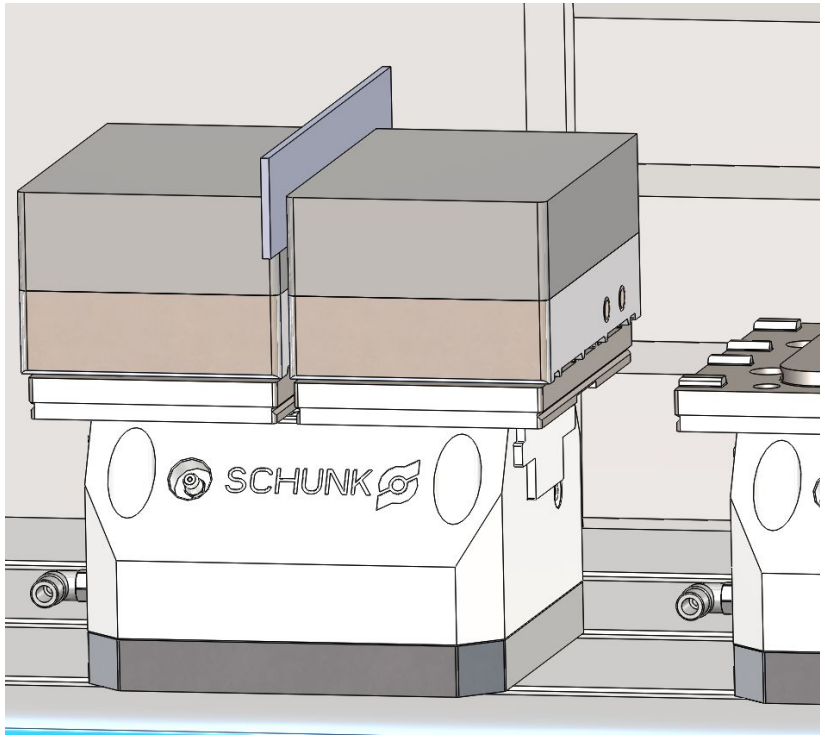
Cutting MultiGrip Jaws

- 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
- 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 cut
- Set the vise clamping pressure 20% higher than the intended clamping pressure during automated processing or the maximum clamping pressure of the vise



Cutting ID 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 style MutliGrip 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 cut
- Set the vise clamping pressure 20% higher than the intended clamping pressure during automated processing or the maximum clamping pressure of the vise



Vise Wash Program

- The vise wash program is an easily overlooked but critical part of the automation process - it is worth your careful attention and time to get right
- The vise wash program is a CNC program whose primary objective is to remove chips from the empty vise that is about to be loaded and to position the CNC table for loading and unloading by the robot
- A secondary objective of the vise wash program may be to remove excess coolant from the MultiGrip jaws that will be unloaded after the wash
- Vise wash will run twice per two operation part - it should be thorough but not waste time
- Flood coolant is often the best tool to remove chips from the vise; when using through spindle coolant use a tool holder that will flow a lot of coolant instead of a small diameter high pressure flow
- A chip fan can be used to remove excess coolant from the part to be unloaded
  - Flood coolant is generally superior to a chip fan for removing chips
  - Chip fan speed should be set to minimize vaporization of coolant into the air

Vise Wash Program

- Vise wash programs can be operation specific:
  - Vise wash after first operation: wash the first operation vise, then wash the second operation vise - this can help prevent chips being washed off the part and jaws in the first operation vise from being washed onto the second operation vise that is about to be loaded
- Vise wash programs are generally developed as sub-programs and added to the bottom of each machining program just before the end of the program
- Vise wash program must be added/called at the bottom of each CNC machining operation program and perform the following:
  - Wash at least the vise that is about to be loaded
  - Position the CNC table in the home position for robot load
  - If using VersaBuilt's Robot2CNC, set the completion flag variable to signal that the machining operation completed successfully

Dry Machining

- The MultiGrip workholding system was designed to be used with CNC machine coolant as a lubricant
- If coolant is available in the CNC machine, use coolant during the wash program to clear chips and keep the MultiGrip workholding system lubricated
- If coolant is not available in the CNC machine, the MultiGrip workholding system must be lubricated using a dry lubricant
- Dry lubricant must be applied to the Vise Intermediate Jaws, the vise interface and gripper interface of the MultiGrip Base Jaws and Fixed Jaws and the interface between the MultiGrip Base Jaws and Top Jaws
- Generally lubricant should be applied every 12 hours but more or less frequency may be required to prevent automation processing errors

Other MultiGrip Jaw Design Constraints

- Using the following design constraints will provide long life to all of the MultiGrip system components when used at air pressures up to 150psi
  - Maximum overall height of jaws: 3”
  - Maximum Y part center offset from center of jaws non-rectangular parts:
    - 1.25”
  - Y part center offset from center of jaws for rectangular parts:
    - For parts less than 2” in length: ¼ of part length
    - For parts greater than 2” in length: at least 1” of part length either side of center

Fundamentals of Successful Automation

Section 6

Fundamentals for Successful Automation

- Transitioning from operator to robot CNC machine tending is best done in steps
- A successful automation process starts with understanding the CNC process and shifting towards controlling the CNC process through scheduled activities as opposed to operators reacting to changes they observe
- Automation can be introduced when there is an understanding of how long (or many parts) can be run before before operator intervention is required and a schedule is in place to ensure the necessary activities are performed by an operator to assure CNC process success
- Initially, the automation process may only run a short time before the operator is required to measure parts or make adjustments to the CNC process
- As the CNC process is better understood, improved and controlled, the automation process may be able to run 24 hours or more without operator intervention

Fundamentals for Successful Automation

- Step 1: Start by assessing how the current operators keep the CNC machine tending process successful
- What is the operator doing to maintain the CNC process and how often?
  - Measuring parts
  - Adjusting tool wear offsets
  - Washing down chips
  - Adding coolant
  - Cleaning coolant tanks or filters

Fundamentals for Successful Automation

- Step 2: Create a schedule to maintain CNC process control
  - With an understanding of what operators do to maintain the CNC process, measure how frequently they do it and make a schedule to ensure those steps are performed on a schedule instead of by intuition or reaction to a failure
  - Typical items on an initial CNC process control schedule might include:
    - Part inspection
    - Tool wear offsets and tool replacement
    - In CNC chip wash down
    - Emptying chip bins
    - Coolant levels and concentration

Fundamentals for Successful Automation

- Step 3: Introduce the automation process
  - Follow manufacturer's guidelines for process and fixturing
  - Emphasize simplicity and reliability in the automation process over speed
  - Start by monitoring process closely, carefully investigate any failures, determine root cause and adjust process as required
  - If available, use spindle probe, tool probe and tool breakage detection to monitor and control the CNC process

Fundamentals for Successful Automation

- Step 4: Expand the scope of and improve the CNC process control schedule
  - Objective is to increase process reliability and time before operator intervention is required
  - Chip management: observing where chips collect, mitigating chip collection in the CNC using auxiliary coolant or other means, understanding how often operator intervention is required to prevent CNC process problems
  - Predictive tool management: measuring how long tools last and using that data to define tool inspection or replacement periods; use of CNC control to expire tools or swap in backup tools
  - CNC maintenance including maintaining coolant levels, oil levels, filters, sumps, vises, chucks, tool holders, spindles and verifying machine accuracy
  - Move towards relying on understanding, measuring and controlling the process to make good parts

Fundamentals for Successful Automation

Develop processes that handle a wide range of variability then control and minimize variability in the process