ROBOTIQ

BUCHANAN AUTOMATION INC.

Since 1963

The Machine Tending Playbook

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Introduction

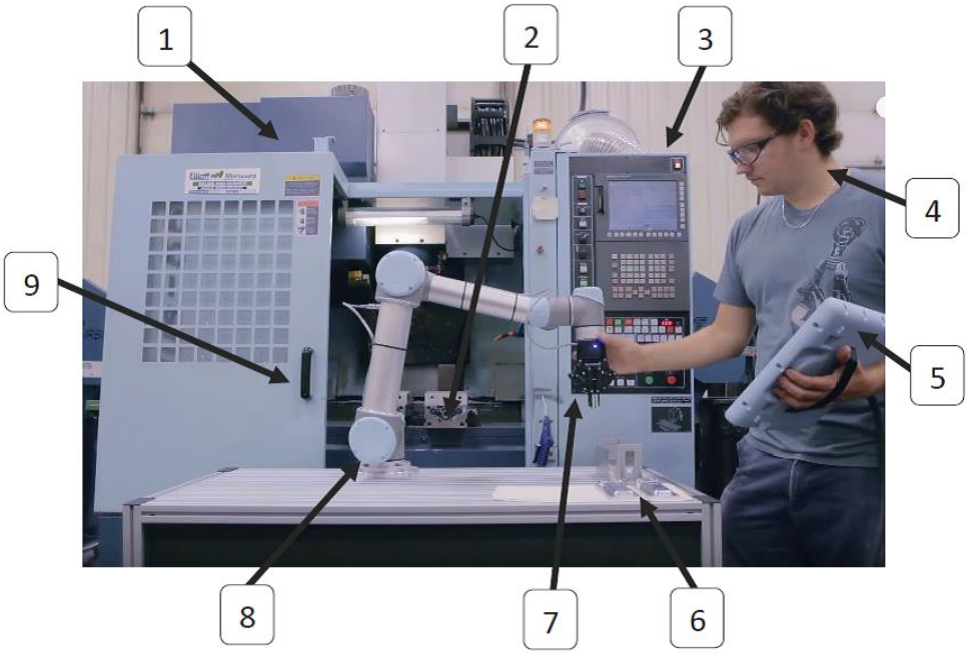
Machine tending applications generally involve autonomously operating machines, like CNC machines. According to the Oxford English dictionary, machine tending is "the action of supervising or tending a machine in operation, especially by performing routine checks and maintenance or ensuring the continuous supply of materials, as on a manufacturing production line; frequently with pejorative connotations of undemanding and tedious work."

We are most interested in the removal of the 'pejorative connotations of undemanding and tedious work' through the use of automation. Thus, in this eBook we will explore how to improve your CNC machine production through the addition of a robot.

To give you a first look at what is involved with a robotic machine tending cell, you may want to take a look at this video.

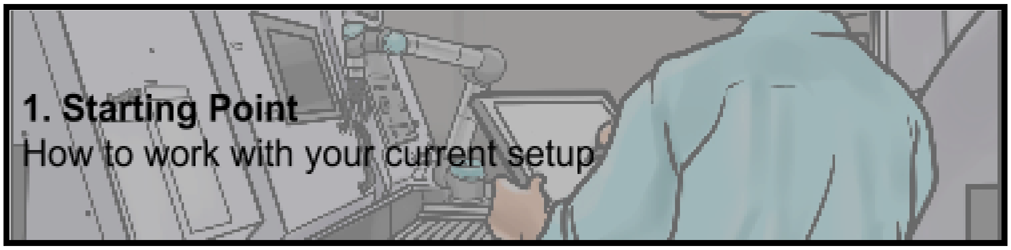
In this eBook you will learn how to determine the baseline requirements for your application and how to build a return on investment assessment. We will also discuss how to evaluate your production with a focus towards introducing a robot while optimizing its implementation. Finally, you will have access to insiders' discussions on machine tending implementation through our DoF community.

Anatomy of a Machine Tending Cell

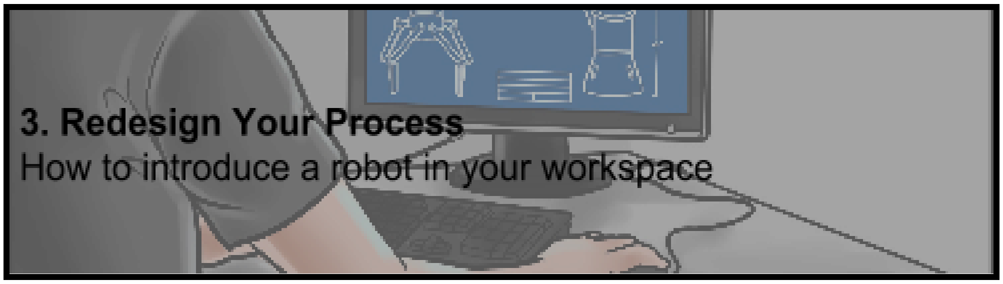


1. **CNC Machine:** CNC stands for Computer Numerical Control: a machine that can autonomously machine parts.
2. **Vice:** Mechanical device that hold parts while they are being machined.
3. **Controller:** The part of the machine that calculates and controls the motions of the machine.
4. **Operator:** The worker who is operating the machine and will operate the robot.
5. **Teach Pendant:** The robot's user interface: it is used to send requests and program the robot.
6. **Parts:** The part goes into the machine, generally one at a time as raw material, and comes out machined.
7. **Gripper**: The machine tending cell will require a gripper to grasp the raw material and load it into the machine. It will also be needed to collect the machined part after the transformation process.
8. **Robot:** An articulated robotic arm can perform the tedious actions of loading and unloading parts for the operator, including opening and closing the CNC door.
9. **CNC Door:** Must be closed while the machine is running, for security this keeps metal debris confined within the CNC and prevents part projection.


0. Estimate Your Production
Evaluating your current production to establish baselines


1. Starting Point
How to work with your current setup


2. Process Analysis
How the robot does the operator's job


3. Redesign Your Process
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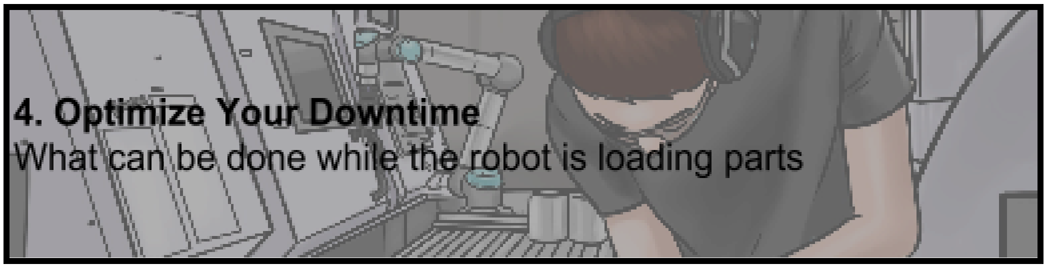
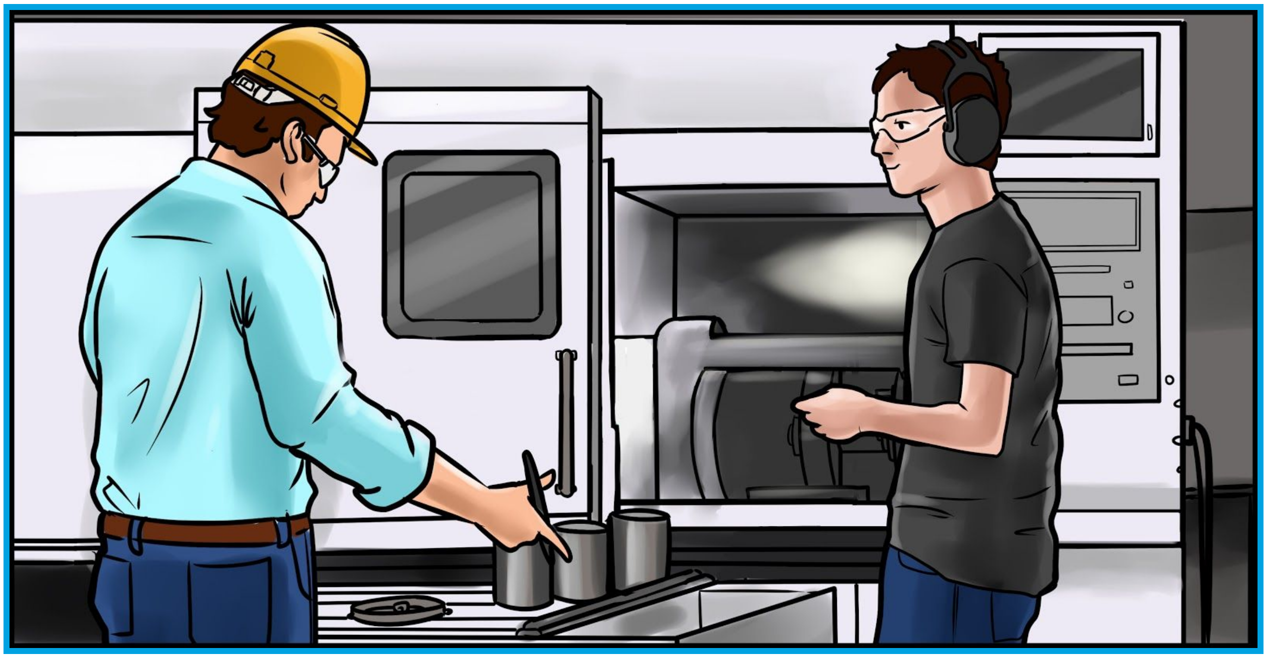

4. Optimize Your Downtime
What can be done while the robot is loading parts


5. Return on Investments
How can you prove a fast ROI with data

0. Estimate Your Production



From previous experience, we have noticed that most companies that are thinking about introducing robots into their machine shop have never actually tracked their production. When trying to justify the purchase of a robot to management, or to calculate return on investment, the production team had no baseline. In order to get a starting point, we recommend monitoring your current cell to see if your robotic investment will be worth it.

Production Rate

The production rate is your production cadence. It can be expressed as a daily, weekly or monthly figure depending on your production type. Once the robot is operational on the shop floor, you should aim to see your production increase or at a minimum remain stable.

Pro Tip: Calculate all your production rates using the same bases and keep a spreadsheet with all your times and production rates correlated according to the same time of year. This way you will be able to see the impact of the robot on your production in graph form.

Spindle Time

This metric can have different names (chip time, running time, uptime), but basically it means the amount of time the machine spends is cutting metal during a day. If your machine worked 12 hours out of a possibility of 24, then you have a 50% spindle time.

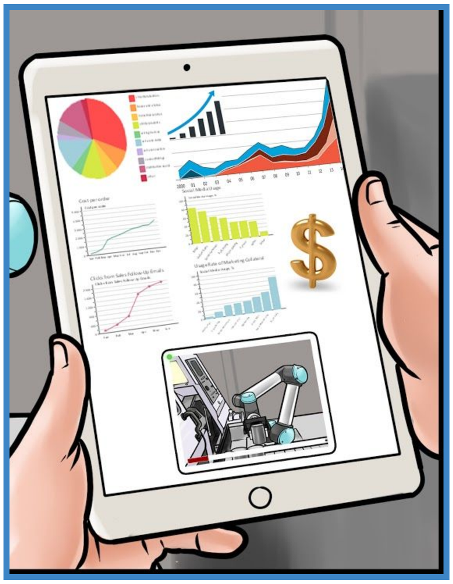
Pro Tip: Since you know your CNC program time and know how many parts you can produce in a day, it is easy to calculate your spindle time.

Program time X Number of parts produced in 24h **= Spindle time in 24h**

This metric can be expressed in minutes or hours. This is the metric you really want to increase when adding a robot to your CNC machine process. If you can run your machine 5 more hours during the night, your spindle time passes from 79% (19/24h) to 100% (24/24h).

Quantity of Defective Parts

As a machine shop, the difference between success and failure is often the number of good parts you can produce, compared to the number of defective parts. If you are running a machine for a couple hours and the parts that come out of it are defective, you have simply wasted all that production time and raw material, plus the wear and tear on your tool.



So what you want to do is reduce the amount of defective parts to increase your productivity. In order to do this, you need to know your defective part baseline. In any case, you need to monitor all your defective products to find the reason(s) why they did not meet specs.

Pro Tip: You probably have the whole history of your wrong parts and you know exactly the time you spent machining them. Calculate your Defective Cost baseline and try to reduce it in the next production of the same product.

Spindle cost per parts X Number of defective parts = **Defective Cost**

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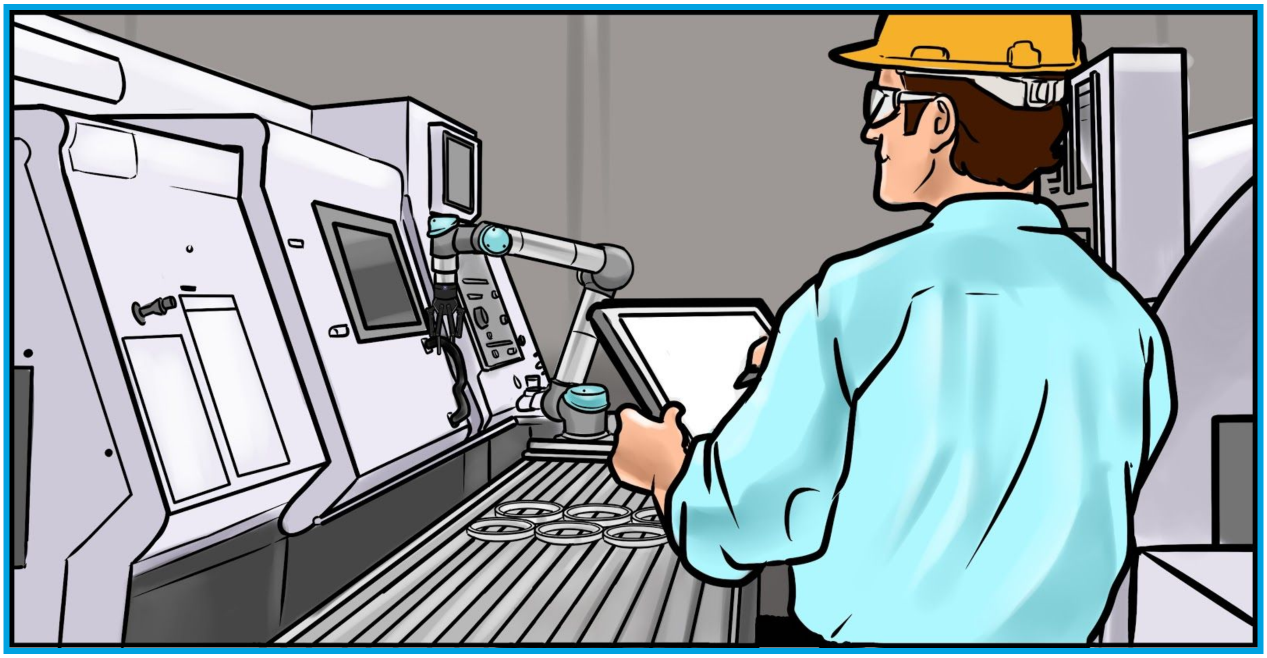
Log all these metrics in a simple excel sheet with graphs or pie charts and pin it on the lunchroom wall. As the time goes by you will see how your machine tending integration has impacted your productivity.

1. Starting Point



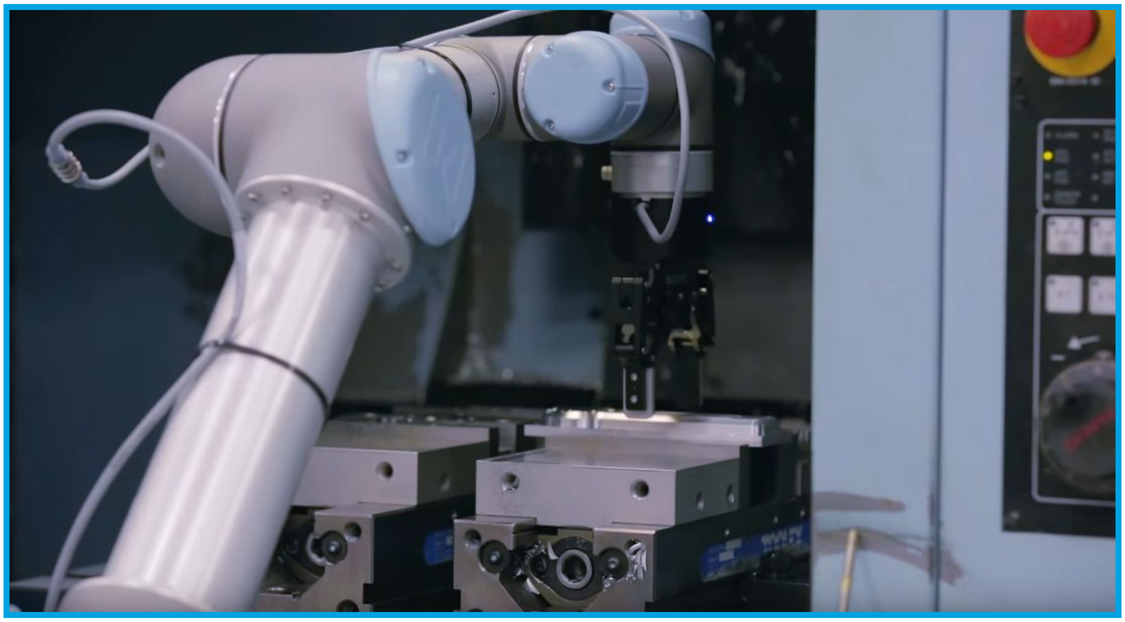
If you are reading this eBook you are probably in one of these 2 situations:

1. **You may already have a CNC machine up and running and you want to install a robot in front of it.**
2. **You are looking for a way to optimize your production and you are going to buy a brand new CNC machine and a robot to achieve your goal.**

Note that each of these situations will have a different impact on your machine tending integration.

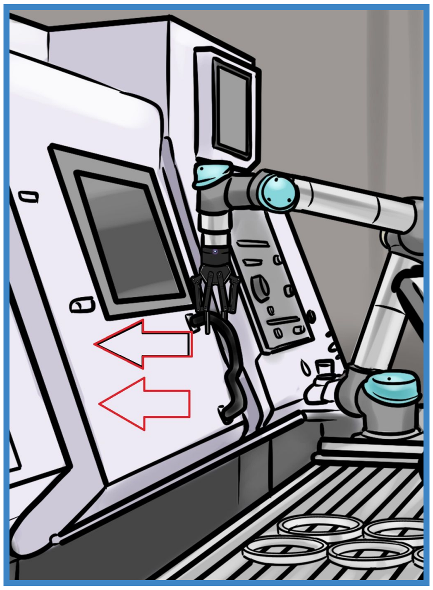
Automated Vise

As you are going to load and unload parts on an unattended machine you should use a vise or a chuck that will open and close automatically. Most automated vises are air powered. This means you will need a small Programmable Logic Controller (PLC) or some way to send signals to the vise indicating when it's time to open or close.

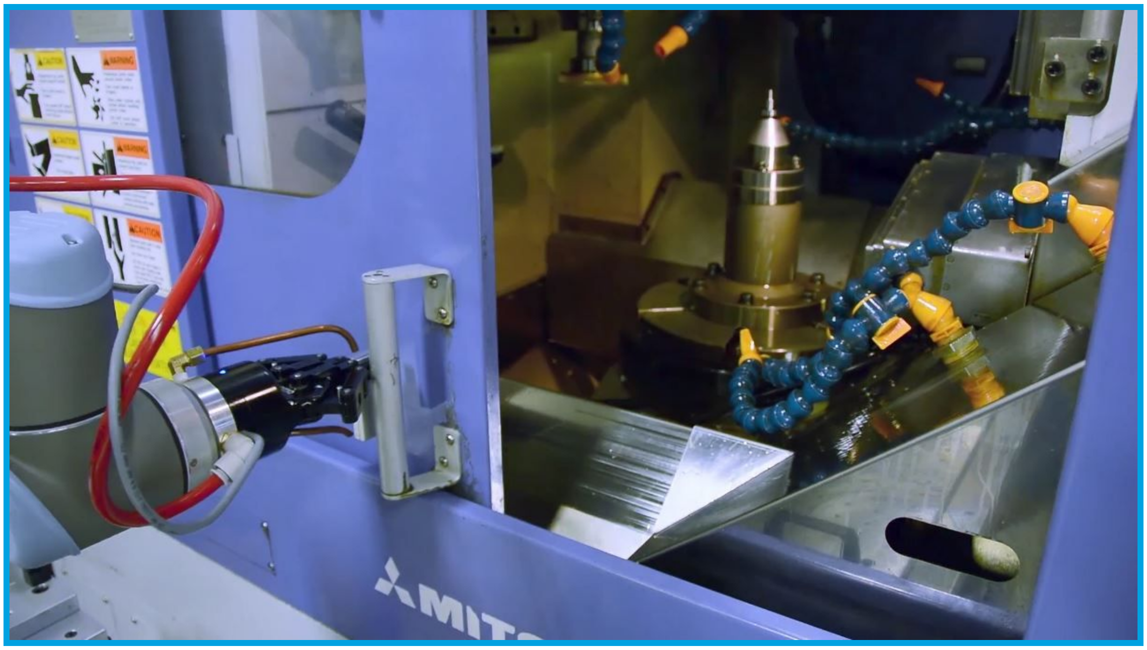


Pro Tip: Make sure to have a vise with adjustable pressure. This will allow you to grab both fragile parts and big bulky ones when the need arises.

Actuated Door or Not?

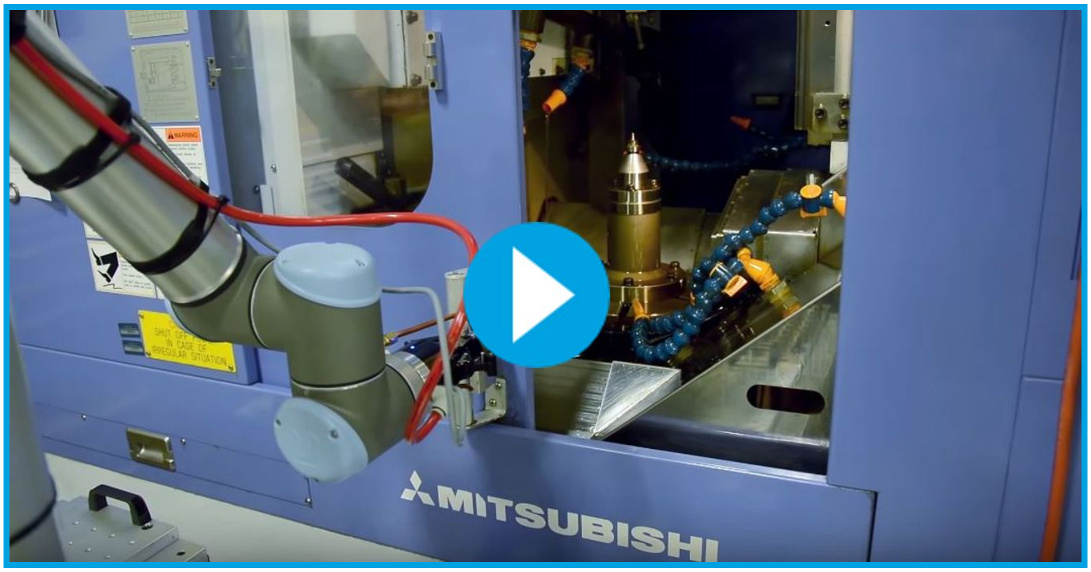


There will come a time in your integration where you will have to decide if you need an automated door or not on your CNC machine. If you are buying a brand new machine, take this option. The costs are generally worth it. If you are keeping your old machine, and want to improve your machine tending with a robotic arm, you have the option to open and close the machine door with the robot instead of an automated signal. We have seen a lot of integration projects where the robot was closing the door of the CNC machine and it works perfectly.



Pro Tip: In order to simplify your integration process, you can start your robotic program using the door signal as a trigger. In fact, with an automatic door, when the door opens, the CNC process is completed. This can then be the trigger for the robot arm to retrieve the machined part and insert a new raw piece.

Following are some real life examples of integrations with different types of door management.



Example of a door operated by the robot. In this case, the robot was added to the existing machine. There was no actuation system on the door, so the user decided to simply replace the operator's action with the robot.

Example of an actuated door. In this second case, the machine was bought in conjunction with a robot. In order to ease the integration, the company chose a CNC machine with an actuated door.

This topic leads us to the next important and really touchy aspect of robotic integration in machine tending: Communication !

I/O Available: Communication

There are a lot of different signals that you can get from a CNC machine and from the robot. In order to make these 2 devices talk together, you need to have a communication port available to connect one with the other. For machine tending specific applications, a total of 6 I/Os are needed.Here are the different I/O's that your machine and robot should output. Notice that you can trigger pretty much everything to allow the CNC nor the robot to the next step.

CNC to Robot	Robot to CNC
1.JOB_FINISH	-
-	2. PART_GRIP
3. CHUCK_OPEN	-
-	4. NEW_PART_IN_PLACE
5. CHUCK_CLOSED	-
-	6. DOOR_CLOSED

1. JOB_FINISH: The CNC is done machining its part and is ready for another one. You can use the light signal or anything that is easy for you to detect the end of the program. The robot can then open the CNC door and go in the direction of the part.

2. PART_GRIP: The Gripper has grasped the part correctly on the CNC chuck or vise.

3. CHUCK_OPEN: The trigger to start the unloading part of the robot program. The robot will take the finished part out of the machine and grasp a raw one.

4. NEW_PART_IN_PLACE: The robot has placed the part in the machine vise/chuck and is ready for it to close against the part.

5. CHUCK_CLOSED: The chuck is closed against the part and the robot can make its way out of the CNC and close the door.

6. DOOR_CLOSED: The robot is out and the door is securely closed. The CNC can then start its program again.

You will have a bunch of other steps between these keys steps. These are the most important ones to communicate between your 2 devices.

To have a better idea of the difference between digital and analog signals, read this discussion on DoF.

Measuring Parts With a Probe

If the location of a part is extremely important for your milling machine, you should use the probe in your machine to set the position of the raw part that was just placed in the machine. In fact, if your raw material is trimmed with very little surplus material available to work with and you need to cut a super precise first cut, you may want to know the exact position of the raw part. Having the exact positioning of the raw part will eliminate your chance of running an empty machine and reduce your chance of making a wrong first cut.

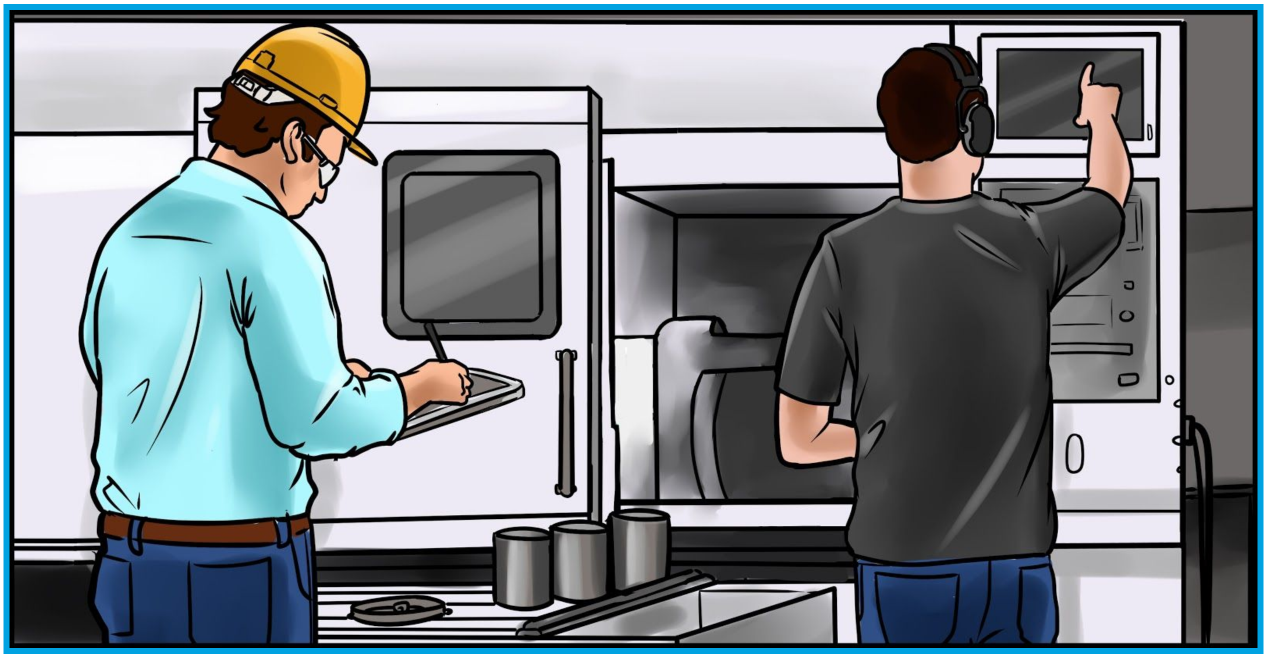
Pro Tip: Take a point in the Z direction and one in the opposite axis of your vise jaw. Since you know the position of your jaw, you don't want to remeasure this value.

Take a look at this Renishaw Touch Probe measuring a propeller inside a CNC lathe.

Now your current or potential machine has all it needs to be fitted with a robot. Next, you will have to figure out how to coordinate your robot with all these options.

To get there, start by analyzing your human operator's machine tending process to anticipate how the robot will be used. Since robots aren't human, you don't need to accommodate them with breaks or facilities to keep the workspace ergonomic. This might mean your robot will be able to work faster than a human operator and is only limited by the speed of its companion machines.

2. Process Analysis



A couple of years ago I heard a graduate from a robotics program say this: "It's hard not to be disappointed by a robot''. He was right.

When talking robots with outsiders, they often have preconceived ideas about the great things robots can do. They imagine robots can do a bunch of complex tasks. Unfortunately, today's robots are probably unable to accomplish what you think they can. In other words, a robot is limited compared to a human.

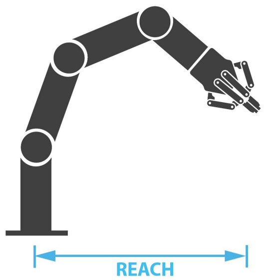
While the news (and the movies) is always full of futuristic robots that can do a lot of things, industrial robots can often do much less. In this part of the eBook we will talk about the analysis of your process in order to fit with the robot's limitations.

2.1 Robot Limitations

This section contains a simple list of limitations that you need to consider when designing your automated machine tending cell. Most robot arms can do a limited amount of manipulation and decision making, because of their mechanical or electrical limitations. The following tips will help you figure out what to look at when shopping for a robot.

Robot Reach

A robot's reach is the working envelope of the robot. Since this envelope is limited, you will need to place all your processes into this workspace. If you want your robot to grasp parts, use a tool and open a door, all of this has to be accomplished within the robot's working zone.



Note that the robot is most likely to trigger an error message if it carries a high payload near its maximum reach. This should be considered in your preliminary design. Here's a helpful cheat sheet on different robot specifications for your robot selection process.

Pro Tip: Most people will try to insert a robot in the exact same working environment or conditions than a human worker. In most cases, this working area will probably be too large for the robot. Bring your devices closer to the robot in order to make everything work correctly.

Robot Payload

The robot's payload should be one of the main specifications to consider in your robot selection. The payload should include the weight of the part that will be carried during the operation and also the weight of the tool used.

Since your robot will carry different types of parts, you will need to determine which parts will be the heaviest and select your robot consequently.

Let's see how you can calculate your raw part weight:

If you have a raw stainless steel cylinder that is 76.2 mm (3 inches) long with a diameter of 100 mm (4 inches).

Part Weight [kg] = Density [kg/m^3] * Volume [mm^3] * Conversion factor [1m^3/1x10^{9}m^3]

Part Weight [lbs] = Density [lb/in^3] * Volume [in^3]

Where the density of the stainless is 7900 kg/m^3 (0.28 lbs/in^3) and the volume of the part is ($V=pi*r^2*h$) 598,474 mm^3 (141.37 in^3).

The weight of the part is 4.72kg (10.55 lbs).

If this is the heaviest part that you will be carrying you can use a robot with a 5kg payload or more such as the Universal Robots UR5 or UR10. You should also consider the weight of your tooling in your weight calculation in order to make sure it is within the allowable payload. In this example, you would need to use a gripper that is under .28kg to meet the UR5's payload requirements or a end-effector up to 5.2kg. In order to have good accelerations your total payload should remain within 90 to 95% of the robot payload. In his case, the UR10 would be better option.

Here's a cheat sheet on different robot specifications, this can be helpful in your robot selection.

Pro Tip: In order to have safe robot acceleration and speed setting you should carry a weight within 90%-95% of the maximum payload. In fact, carrying a load too close of the robot maximum payload can put the robot in error and stop your program.

D o F

Gripper Dexterity

Grippers or end effectors often have very limited dexterity. If your application requires the operator to handle several different parts at the same time and perform operations with both hands, you will need to review these operations carefully, because robots can only do one thing at a time in sequence - and have only one hand!

This doesn't mean you can't use robots for this process, but it probably means you will have to redesign your process. If you are redesigning your process correctly, this can work perfectly.

In machine tending applications most of the human operator's manual process will include part placement, tightening the vice and starting the program. Then, doing all these tasks in reverse order when the part is processed.

For the robot to place the part in the machine, you will need to use mechanical stops or other devices to place the part correctly.

To tighten the vice, you may want to use an automated vice. Such devices will allow the robot to place the part and then the vice can tighten the part automatically.

Finally, to start the application, you either push on the start button with the robot or use the PLC to send a signal to the CNC to automatically start the program. We strongly recommend against using timers, as CNC machines are not as precise in their timing as you'd expect, and timers to not adapt to exceptions happening in the milling process.

It is unrealistic to expect a robot integration to have no impact on the human process, since robots do not have the same dexterity and flexibility as a human worker. However, tasks can be simplified and broken into simpler, easily automatable tasks.

Gripper Stroke

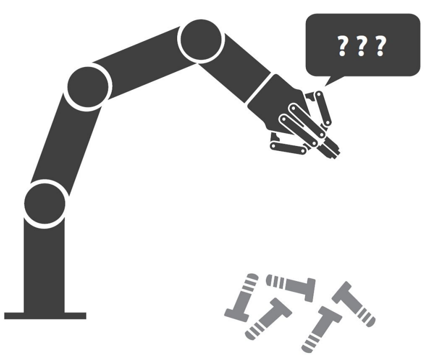
Your gripper selection will depend on the parts you will handle. If you are handling parts between 5mm to 80mm you should choose a gripper that has the flexibility to adapt to all these lengths. Robotiq's 2-Finger 85 Gripper can accommodate parts within these dimensions without any additional programming.

If you are only handling one a 27.5mm part all year long, you may want to go with a custom gripper that will perfectly fit your part.

> Pro Tip: Using a flexible Gripper will allow you to take raw and finished parts with the same Gripper. Using a 2-Finger 85 Gripper will also allow you to adapt the force of the Gripper in cases where the finished product is more fragile than the raw part.
>
> D o F

2.2 Robot Intelligence

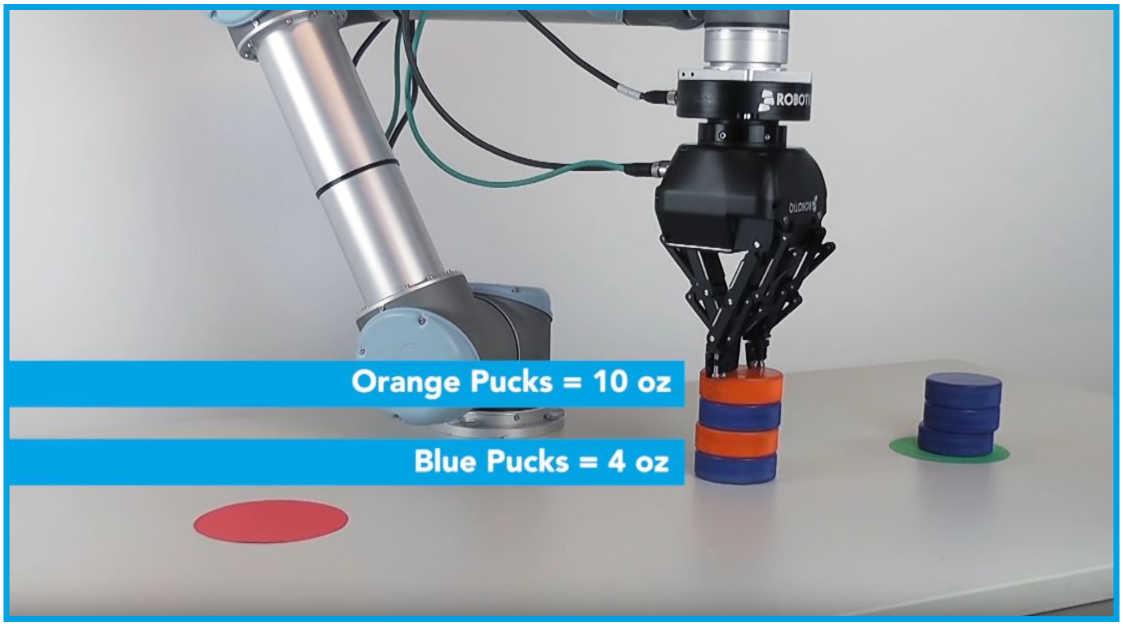
A robot will do what it has been taught. In fact, there are very few logical decisions that can be entirely done by a robot. In this section, you will see what type of signal or input can be given to the robot in order to allow it to complete its task.



Decision Making

Most robotic newbies will talk about their future robots like: “The robot will do this and that according to situation A and B.’’ In reality, the robot will not do or decide anything, it will simply execute its programming. There are very few decisions that can be taken by the robot. The decision will be made according to specific data.

For example, a robot might be weighing parts and then ‘deciding’ if the part is going into the right bin or in the left bin. In this particular case, the parameter is not: “Is the part heavier than the previous part”. It is rather: “Is the part under 10oz; if yes, drop it in the right bin; if not, drop it in the left bin”.

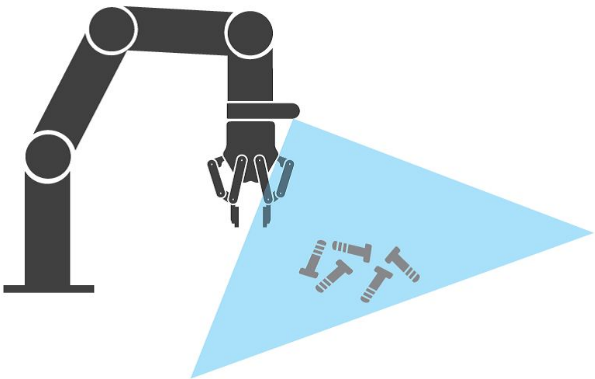


Universal Robots UR5 weighing parts using an FT 150 Sensor and a 3-Finger Adaptive Gripper.

Finding Parts

Not so long ago, it was really complicated to have a part recognition system. Robotic vision systems are relatively new to the market. With built in solutions such as the Robotiq Wrist Camera and the vision system included in YuMi; it is quite easy to locate a part.

This type of technology is growing so fast that even Google has robots learning to pick objects using their vision system. After putting all the data together they can build their own vision library which can grasp parts with more ease overtime.



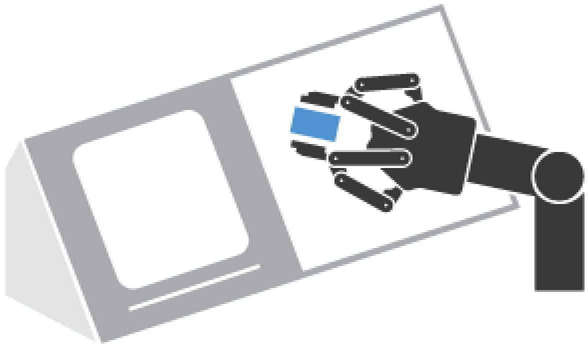
That being said, if your process needs to use a vision system, it is now easier than ever to introduce it.

Pro Tip: Use the vision system in a simple application such as grasping a part on a flat surface. Trying to grasp a part with a complex background (such as a CNC machine) can be complex for the vision system. Since there are a lot of variables, color and reflection, it is hard for the camera to recognize the part correctly. Keep it simple, robotic vision is still an ongoing process

DoF

Communication with the CNC

Since there are a bunch of signals that can be sent from the CNC or from the robot and there is a limited number of I/Os that can be treated by the PLC, it is a good idea to limit the data that you would like to access. You should set your priorities on the signals that are necessary for your machine tending to operate efficiently.



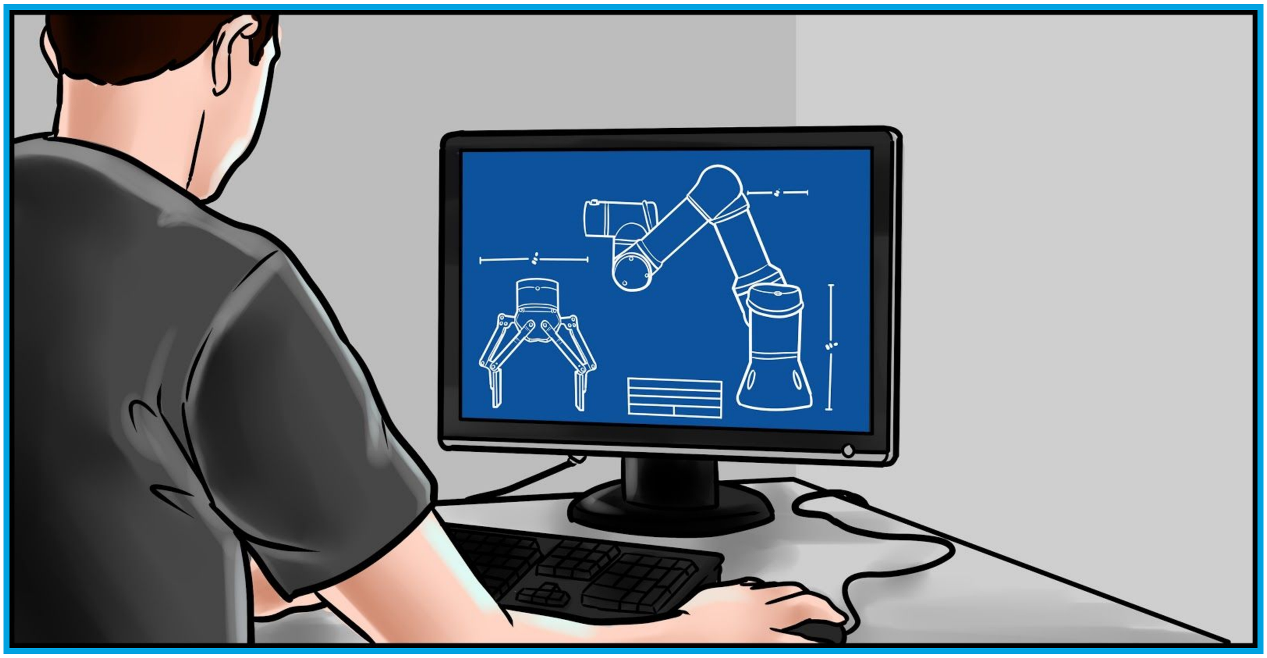
As this discussion on DoF explains, you can use a simple signal from the CNC machine to start the robot program i.e. a light signal, but you can hardly extract enough precise data from the CNC to trigger your robot. Keep the communications between the robot and the CNC machine as simple as possible, this will simplify your integration and keep you away from complex logical decisions.

Pro Tip: To trigger the start or the end of a program, use discrete values (i.e. end position, proximity sensor signal or light signal) and not variables (i.e. distance, position, current and force). This will trace strict barriers between a go and a no-go by leaving no place for interpretation.

Process analysis is all about translating the current manual operation into an automated robotic manipulation. Choosing the right devices for your application and trying to keep it as simple as possible will always help. Managing too much sensor data or too complex a cell can make your robotic project more frustrating than it needs to be.

Keep it simple: make sure you have everything you need to make the robot cell efficient and nothing more.

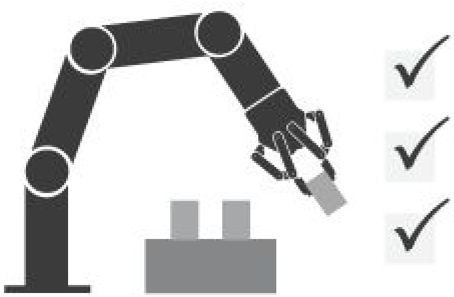
3. Redesigning Your Process



For the next step of the machine tending integration process, it will be helpful to reconsider your process. As your robot is limited, adapting your product or your work cell is likely mandatory to creating a system which can work smoothly and efficiently.

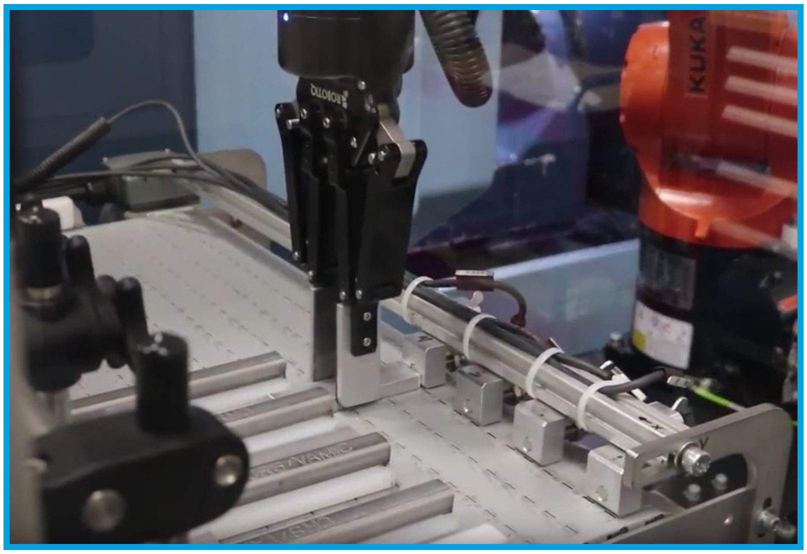
Product Redesign

Since you are in the machining world, most of the products you will be producing are for customers who have very specific requirements. You can probably not change a lot of features on the final product. However, you can still adapt your setup to the robot. If your gripper works best grasping a certain part width, you may want to leave a feature of this width on the part at the first setup or simply leave 2 parallel surfaces to allow for a better grasp. Doing this will help you load the part for a second machine setup without any problems.



We're looking at what we are designing now from a new perspective and making sure we can [assemble it with a robot](). We're looking at all of our design processes and saying ''If we can't put that together with the robot, we gotta go back to the drawing board''. **- Matt Bush, Director of Operations, Scott Fetzer Electrical Group**

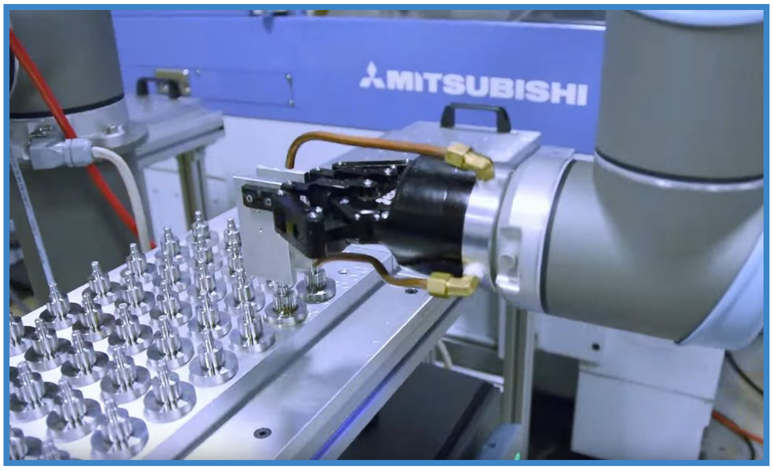
Incoming Raw Parts



Most of the parts you are machining are arriving at the machine in a bin of raw metal all pre-cut to the a set size. However, since these parts are all thrown helter-skelter in the bin, one over the other and one against the other. It is quite hard for a robot to grasp them. To give the robot the opportunity to grasp a part you need to leave some space on each side of the part. That being said, simple trays can be created to allow the robot enough room to grasp the parts. Another option is to place the parts on a conveyor with a proximity sensor that will stop the conveyor once the sensor detects a passing raw part. By doing so, you can place a bunch of parts on the conveyor and stop worrying about the robot's ability to grasp the part.

Pro Tip: A picture is worth a 1000 words, so the following videos will give you a good idea of what can be done with incoming parts.

Machined Part Output



When analyzing your existing CNC part output you may realize that it is using dexterous manipulations. Putting finished parts in a box or a bin looks normal for a human, but it can be complex for a robot. Some of the best machine tending cells we've seen have been working with trays. These simple devices allow a lot of room between the parts and will give you enough space for the opening of the robot fingers once the part is placed in the tray.

Pro Tip: You don't want to do a supplementary operation once the robot has unloaded the parts from the machine. If the part is ready to go, place it in its final destination. A tray or box are ideal to place finished parts. You can also add programming to space the parts and protective material can be placed between the parts, so they don't get smashed during the transport.

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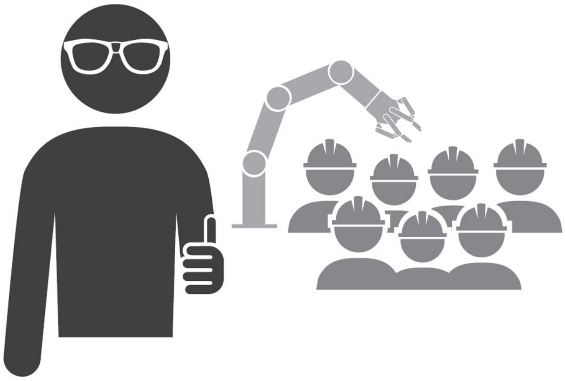
Sensor Management



Your sensors will be your 'eyes and ears' on the robots. Using a lot of sensors will give you a lot of information: you will need to manage all this data correctly to have a functional cell.

Proximity switches and other physical sensors are commonly found on robotic machine tending cells. Even if they are quite useful you will have to manage them using the remaining I/Os in your robot controller or you will need to use a PLC. In either case, the management of your sensors will be crucial if you want the robot to interact with other devices in your cell.

Pro Tip: Safety sensors also have to be managed correctly. Even if you are using a collaborative robot some safety sensors can be added for different reasons. These sensors need to be set on the workflow to protect users. That being said, you will most likely need a safety specific programmable logic controller to manage all your different safety sensors. To learn more about safety sensors, read this article.

DoF

Error Signals

In a human operated cell, the CNC error pops up on the controller screen. As they do their work, the operators see what is wrong with the machine and make the necessary adjustment or stop the machine to avoid anything dangerous. In the case of a robot operating a machine, you need to consider that the robot arm will not automatically stop the CNC machine because there is something wrong. Indeed you need to consider all the error messages in your program.

Pro Tip: One of the most important pieces of advice we can give you is to have a way to confirm that your part is correctly grasped by the vise and Gripper. We have seen a couple of cases where such conditions were not respected and the machine was damaged due to an unclamped part in the CNC. See this discussion about CNC vises on DoF.

DoF

Murphy Analysis

The Murphy Analysis is the “how not to crash my robot” assessment. As there will be a lot of variables that you can’t control, doing a Murphy Analysis will allow you to identify these potential problems and find a solution for them.

Pro Tip: If you are debating about a potential problem and telling yourself it will never happen… trust us it will happen. Make sure to do a legit Murphy Analysis, also known as PFMEA (Process Failure Mode Effects Analysis). This technique will allow you to go through all the machine and robot steps and will prevent potential errors.

D o F

Here are the steps of a Process Failure Mode Effects Analysis.

Stable Processes

To avoid a disappointing robot integration, you should consider that your processes need to be totally stable before even thinking about automating them. Automating a process means that nobody will be watching the machines for a potentially large amounts of time. If the process is unstable, there will be many opportunities for problems to arise and then your production could be wasted. This is not good for quality control. So, make sure to bulletproof your process before you let it run attended.

Pro Tip: Treat your robotic integration as you would with a new employee. Start by giving the robot a simple task. After a couple of hours of operation you will see which parts of the program need to be changed. Do the corrections. Once your program is up and running, strive for a new application or increase the operations in the same cell. Remember, small tasks can save time for the operator and allow him/her to concentrate on complex ones. Just like a new employee.

D o F

The machine tending redesign process can be hard for first timers. However, it is really important to take a step back and analyze what the operator is doing during your assessment process. You will need to do this meticulously in order to translate all this information over to the robotic world. Even if some stuff seems to be easy to do for

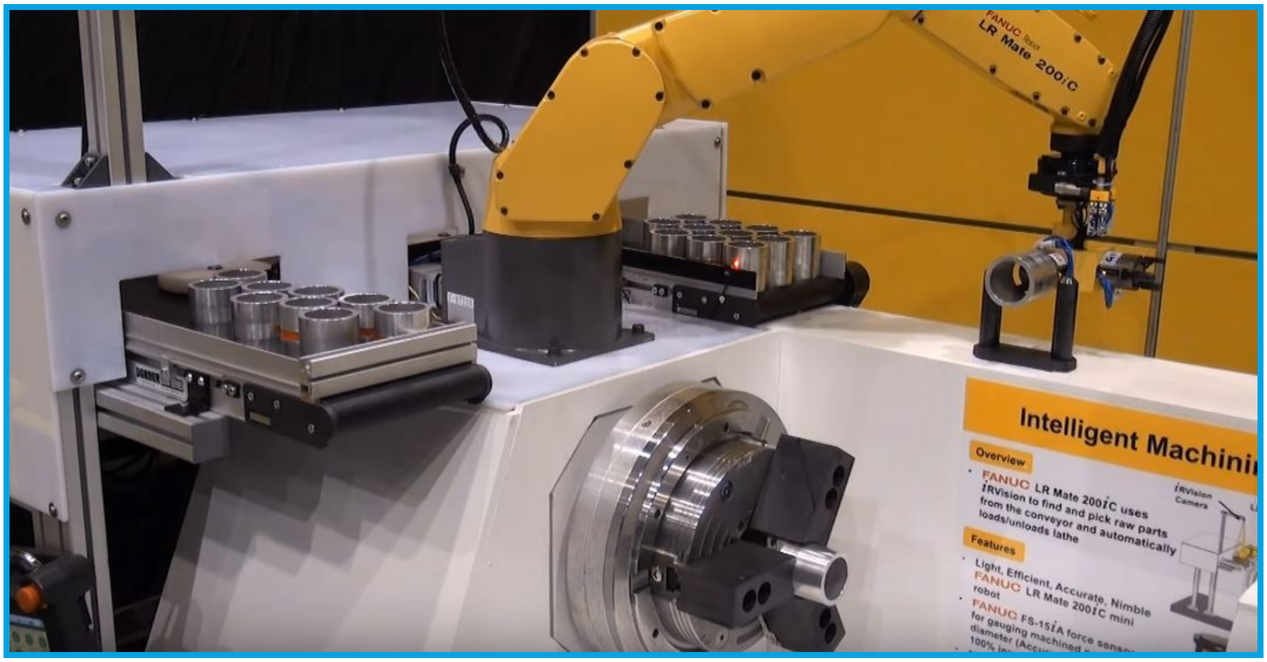
humans, these abilities have to be carefully added for the robot to be able to master them. Make sure to do everything you can to build a 'bulletproof' robotic cell that will work nicely and smoothly beside your CNC machine.

4. Optimize Your Downtime

While the CNC machine is running, you have some downtime you can take advantage of. This downtime can be considered a bonus and can allow you to be ready for the next part to load or to eliminate a future second operation. Now that a robot is tending the CNC, you'll need to think about what to do with the robot as it waits for the machine to finish, it's the robot downtime.

Metrology Process

Several different techniques can be used to measure features on a part. You may want to use the tool inside the CNC machine to make sure the finished part is still right. You can also use an external device or robot tool to measure parts. In the [video](#) below, you can see how a [Force](#) [Torque](#) [Sensor](#) is used to measure the external diameter of a part.



Since this process can be done while the CNC machine is running, you can confirm some part features at the same time and continue your production without any worries.

> Pro Tip: Don't wait too long before measuring parts. Measure a sample every once in a while to make sure your production is meeting standards. This will allow you to catch process drifts early and reduce waste.

Assembly

Depending on the manufacturing stage of the part you are producing, you can explore uwing your robot to perform assembly tasks with the part that comes out of the CNC machine. We have seen some applications where robots were fastening parts together or inserting sealant.

There are a variety of different sub-assemblies that can be done with your robot. Be aware of what your robot arm might be capable of doing to save you time in your production process.

Cleaning

Part cleaning or tool cleaning can be a good way to ensure consistent part quality. Many quality problems can come from dirty parts that create surface treatment problems.

Pro Tip: Here's a good example of tool cleaning between parts. This type of cleaning step does not take a lot of time, but can allow you to have a good repeatability in your part placement.

D o F

Setups

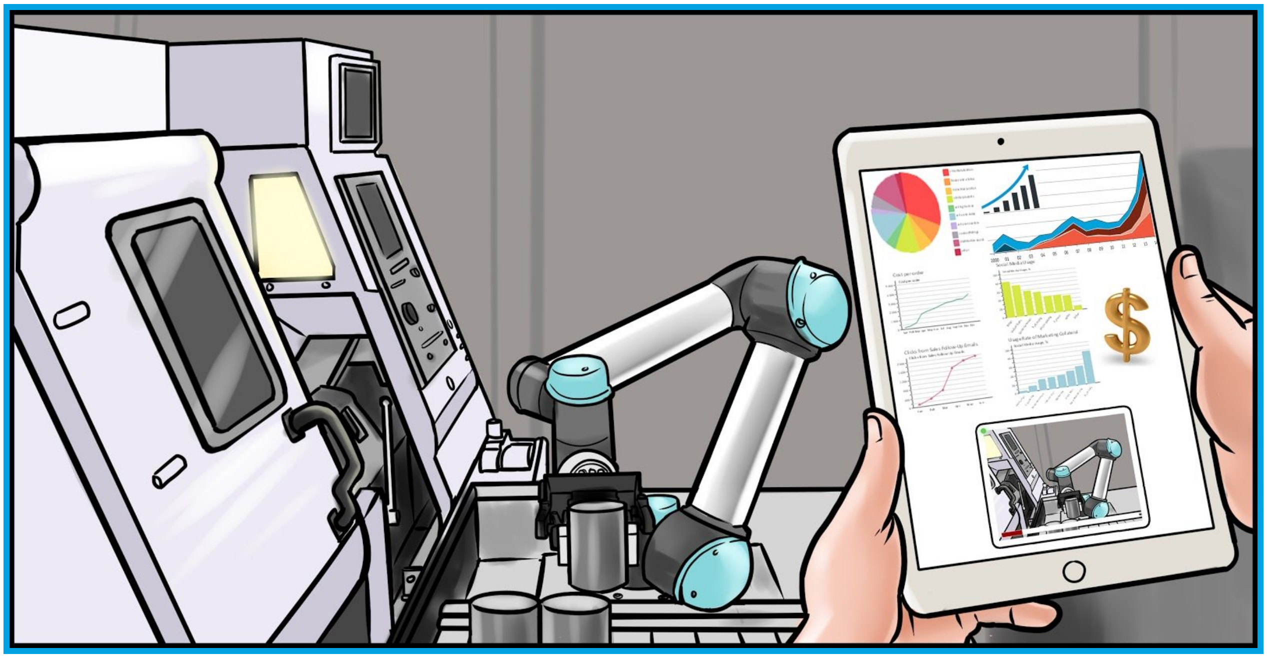
While a robot cannot perform machine setups, your employees can. Since you now have free hours on your employee's schedule, they can prepare for the next production run and reduce the downtime between two production runs. This will help you increase your spindle time and will eventually allow you to output more parts.

Pro Tip: Calculate the change over time between production runs to evaluate your efficiency. The shorter the downtime, the larger the output.

D o F

All these tricks and tips can free up your employees and allow them to do tasks that require dexterity and intelligence. They now have more time to prepare future production or do a second operation. Leave the repetitive and monotonous operations to the robot and let your employees do what they are good at.

5. Return on Investment



You will need to justify the expenses related to the robot you want to purchase to your management. Since you have established your baselines earlier, you can now determine how long it will take until your robot has paid for itself. And better yet, when it will start earning you a profit.

Since return on investment is a subject in and of itself, we will not go into the fine details on how to calculate your ROI. But we do have an eBook that can help you when analyzing your robotic cell in terms of budget and productivity. To have more details about return on investments, consult this eBook.

Payback Period

One of the reasons why you will be using a robot is to enhance your production. Using a time-based calculation makes ROI easily understandable by all. If you can tell your manager that you can reimburse the investment in 6 months, they will have a better idea than if you are telling them the robot will be paid back after 1,273 parts.

The best way to calculate the time it will take for reimbursement is to use the following data.

- The average spindle time before introducing the robot (See section 0. Estimate your Production).
- The production rate before introducing the robot.
- The profit on the finished parts.
- Your hourly machine cost, including the employee cost and the machine cost.
- The robotic cell cost.
- The average spindle time after the introduction of the robot.
- The production rate after introducing the robot.

The easiest way to calculate the time before reimbursement would be to use the spindle time difference between the time when you were not using a robot and now.

$$Time\ Before\ Refunding\ = \Delta\ Spindle\ Time\ =\ (Robotic\ Cell\ Cost\ \ /\ Machine\ Hrly\ Cost)$$

For example if your robotic cell cost 50,000$ and you evaluate your machinery hourly rate to 100$ the time before reimbursement will be:

$$\Delta\ Spindle\ Time\ =\ (50k\$\ \ /\ 100\$/hr)\ = 500\ hrs$$

This means that you will refund your investment when your machine has performed 500 more hours than it usually would on a normal shift. Now. let's say you will now run the machine autonomously during the night shift, which represents 40 hours per week.

$$Time\ Before\ Reimbursement\ =\ 500\ hrs\ /\ (40\ hrs/week) = 12.5\ weeks\ or\ 3.12\ months$$

If you want to push it a little further, you can use the additional profit you are making on the extra parts you are now producing because of an increase in spindle time.

$$New\ Machine\ Hrly\ Rate\ =\ Old\ Machine\ Hrly\ Rate\ -(\Delta Prod.\ Rate\ *\ Profit\ on\ Parts)$$

For example if your production is passing from a 10 to 12 parts per hour rate and you are making a $5 profit per part, you can do this simple calculation:

$$New\ Machine\ Hrly\ Rate\ =\ 100\$/hr\ -(2\ parts/hr\ *\ 5\$/parts) = 90\$/hr$$

That being said you can introduce this value to the previous calculation and figure out your payback period. However, the first calculation can sometimes be enough to convince management of the benefit of adding a robot to your production line.

Connected Robots

Industry 4.0 is the up and coming trend in the robotic world. In fact, this type of connectivity can give you a better idea of how well the robot is working and what are its performance values. You might be able to use a simple device or tablet that will tell you everything you need to know about your robot: working time, the number of parts it is producing and a whole lot more data. This data can be useful for preventive maintenance, but it might also send alerts if the robot has a problem or if it has finished its task.

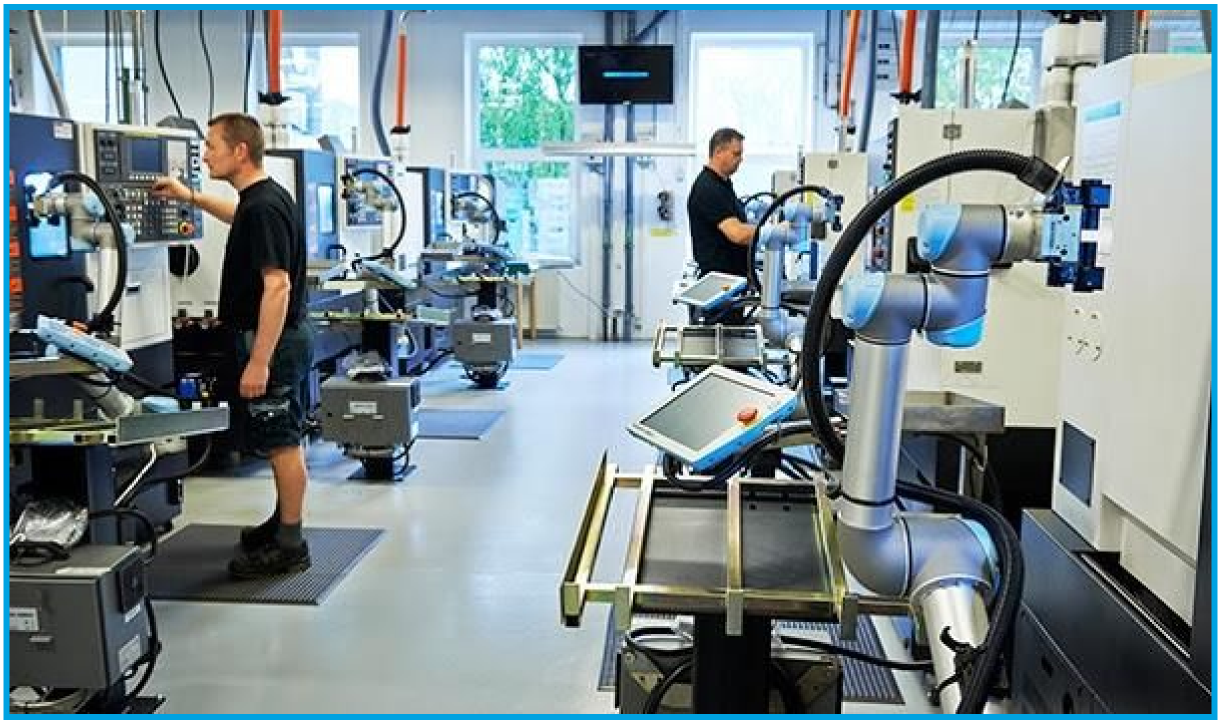
Pro Tip: Having a connected robot is like a having a spotlight on the screws that need to be tightened. Use this technology to do maintenance, but also to increase your productivity by looking at every stage of your robot. If a robot has a job that is done at 90%, you should prepare the next part tray.

D o F

Manufacturers such as OTTO Motors are using Industry 4.0 to coordinate all their robots on the manufacturing floor. Notice that using such devices will help you manage your return on investment a lot easier.

Your Next Robot

As return on investment is not about how much you spend, but how fast and accurately you can produce your parts, you need to keep this data accurate and easy to use. If you present all this data to your manager, you might find that you are be able to have a couple of extra production boxes which will provide enough of an ROI to allow you to order another robotic cell.



Here are some rules of thumb when it comes to payback periods:

- If the project can be reimbursed within 3 months, it is a no brainer;
- Within 6 months, it is mostly a 'go';
- Within 1 year you may need to push a little harder with some more explanations
- Over 2 years, it might be hard to convince your manager (but not impossible it still might depend on your industry).

Perhaps, if the success of your first robot was great and that the ROI was fast, you still have a very good argument to start thinking about another project for your shop floor.

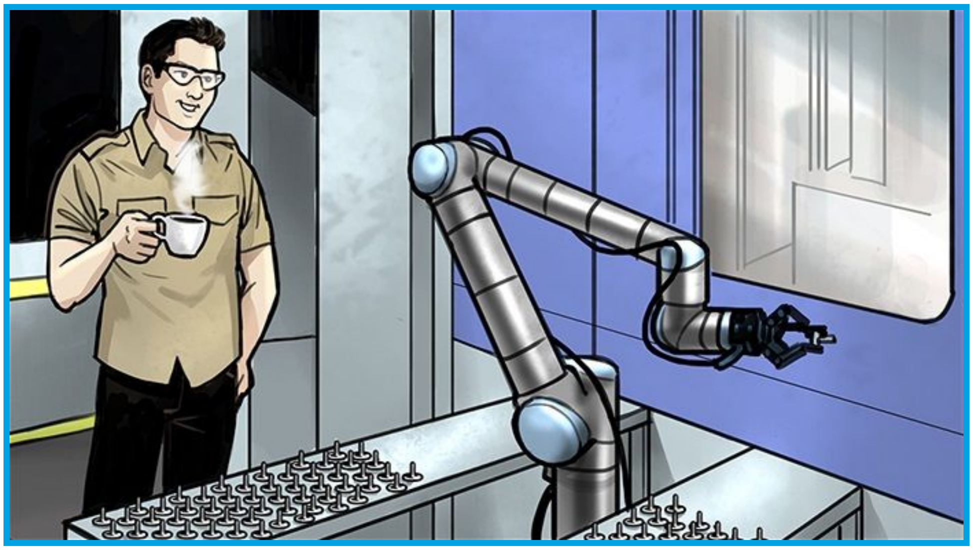
Return on investment allows you to justify the cost of the robot cell. In order to reduce your manager's anxiety over the big numbers he might be seeing, you need to explain how fast you can refund this investment. In most situations, it will be worth it. Here's an example of a machine tending cell that was refunded within a couple of months.

Conclusion

Machine tending is a process that can free your time in the long run. By establishing your baselines and observing your current processes you can work your way to a fully automated robotic cell and make your process a lot more efficient and perhaps even improve your quality control and reduce your scrap parts along the way.

By redesigning your process or your work area, you are making sure you can recreate the actual worker action of your operator in a robotic way. To achieve such a task, adding sensors and devices are a necessity to make your robot feel and see its environment.

Finally, once your robotic cell is integrated you simply need to confirm how long it will take to refund your investment. In the meantime, your employees can do more valuable tasks and use their dexterity to accomplish quality checks and setups that will increase your productivity. If they can oversee production they will be better placed to forestall problems.



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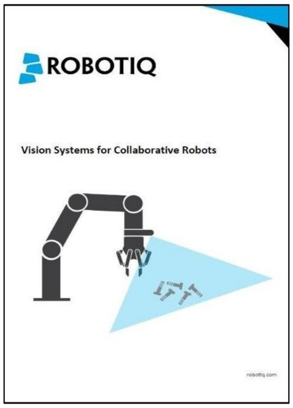

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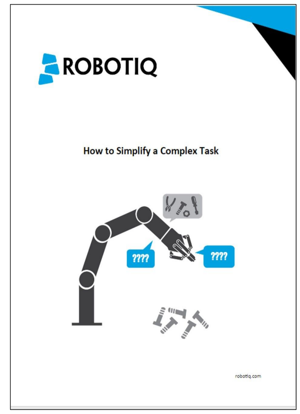

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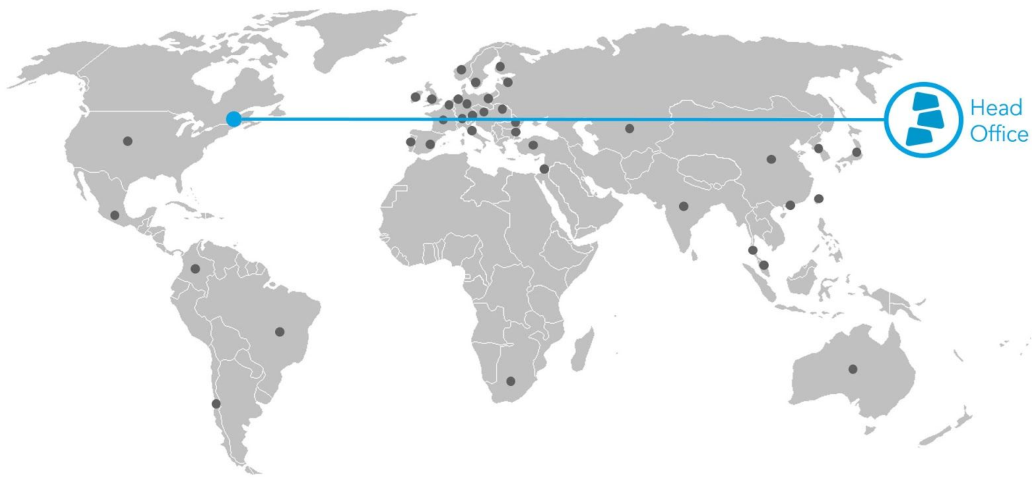
About Robotiq

At Robotiq, we free human hands from repetitive tasks.

We help manufacturers overcome their workforce challenges by enabling them to install robots on their own. They succeed with our robotic plug + play tools and the support of our automation experts community.

Robotiq is the humans behind the robots: an employee-owned business with a passionate team and an international partner network.



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Since 1963, Buchanan Automation Inc. has been the Pacific Northwest's leader in innovative, value added solutions for automation and control systems.

Buchanan Automation is dynamically involved in complex interfacing of electronic and pneumatic controls as well as vacuum systems. Our engineering department utilizes Solid Works, AutoCAD and AutoDesk Inventor solid modeling software to design and synthesize components to better suit any application.

BUCHANAN AUTOMATION INC.

Since 1963

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