PDHonline Course M240 (5 PDH)

AUTOMATION AND ROBOTS

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AUTOMATION AND ROBOTS

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Course Content

Summary:

1. Factory Automation

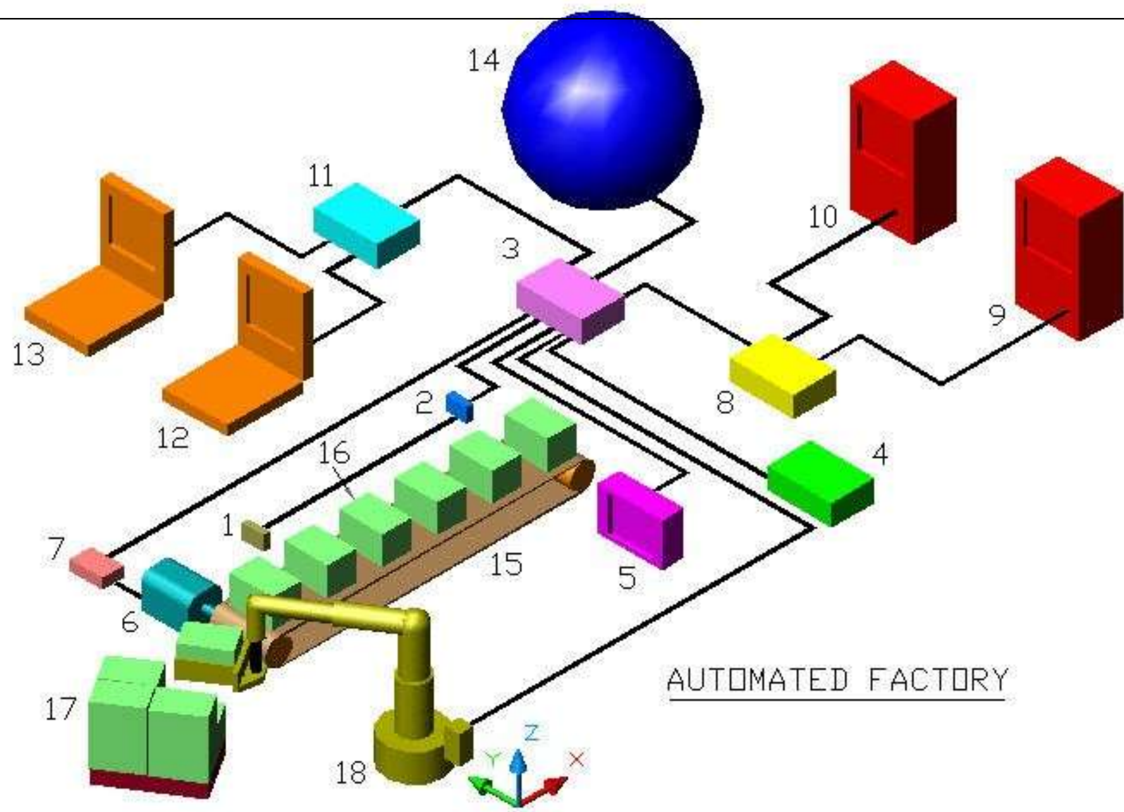
2. Pick and Place Robots

3. End Effectors or Grippers

4. Machine Cell Robots

5. Robot Cost Justification

6. Related Links



Elements of an automated manufacturing system are illustrated above:

1. Laser sensor indicates part is present.
2. Bar code reader.
3. Gateway router.
4. Programmable Logic Computer (PLC).
5. Human-Machine-Interface (HMI).
6. Direct current stepper motor conveyor drive.
7. Variable: angle / speed, controller.
8. Hub to servers.
9. Sever.
10. Back-up Server.
11. Hub to laptops.
12. Laptop.
13. Laptop.
14. World Wide Web.
15. Belt conveyor.
16. Finished product.
17. Packaging for shipment.
18. Pick and Place Robot

Automation with computer integrated systems began in earnest about 1940 and was pioneered by: GE, AT&T, GM, Dupont, IBM, Volvo, Westinghouse, Siemens, Toyota, Intel, Philips, etc.

Automation refers to manufacturing systems with computer controlled robots and machine tools operating from the input of customer orders, through the process of converting materials into finished products.

Varying amounts of human activity are required for the practical implementation of automated systems.

Motor power and automation has moved 75% of the work force in the United States from manufacturing and farming, into the service sector.

Example of the value of automation
The value of an automated system = Value of outputs / Cost of inputs

= $15,000,000 / $7,500,000 = 2.0

Automation Today

Every item and activity in the automated manufacturing plant can be planed, monitored, documented, and controlled with an enterprise resource planning **(**ERP) computer network system.

Every stage of the, material conversion to product, process is documented by barcode printers. Barcode readers transmit data in real time by wireless transmission to server computers.

The dimensions of parts and assemblies are adjusted to comply with customer orders by parametric computer aided design (CAD) systems. Computer software makes engineering calculations ensuring that the new design has the required strength, stiffness, and endurance. These drawings are digitally transmitted to computer numerically controlled (CNC) milling, turning, welding, and painting machines that make the new product models.

The eyes of an automated manufacturing facility are photo-sensing digital vision systems. The hands are grippers on the ends of robot arms. Touch is felt by electronic capacitive and inductive proximity sensors. Quality is measured by laser beams capable of detecting a 0.0005 inch flaw in any of 120 parts passing by every minute.

The company, financial, sales, engineering, and production departments can monitor and control every activity in real time. The organization has become a living, changing, organism.

Process flow through a typical production facility:

Marketing – Advertising and product selection based on projected sales.

Sales – Distributors, inside and traveling sales staff secure orders from customers.

Process Planning – Production systems, flow charts, equipment selection.

Engineering – Product and manufacturing drawings.

Quality Control – Product and manufacturing changes.

Purchasing - Raw materials, standard parts, and equipment.

Receiving - Materials and parts at the Receiving Dock.

Inspection / Documents - All purchased items at the Receiving Dock.

Palletizing - Groups of similar items are loaded onto pallets.

Parking - Materials and parts at machine and assembly cells or on storage racks.

Conveying - Materials to manufacturing and assembly cells.

Machine Cells - Mill, drill, turn, grind, and inspect.

Weld Cells – Joining by melting metal or plastic parts.

Paint Cells – Paint at room temperature or powder-coat at elevated temperature.

Assembly Cells - Bolt, screw, rivet, and inspect assemblies.

Inspection - Dimensions are gauged and parts and assemblies are tested.

Rework / Scrap - Parts that do not pass inspection are scrapped or corrected.

Shrink Wrap / Package - Finished product inserted in boxes and on pallets.

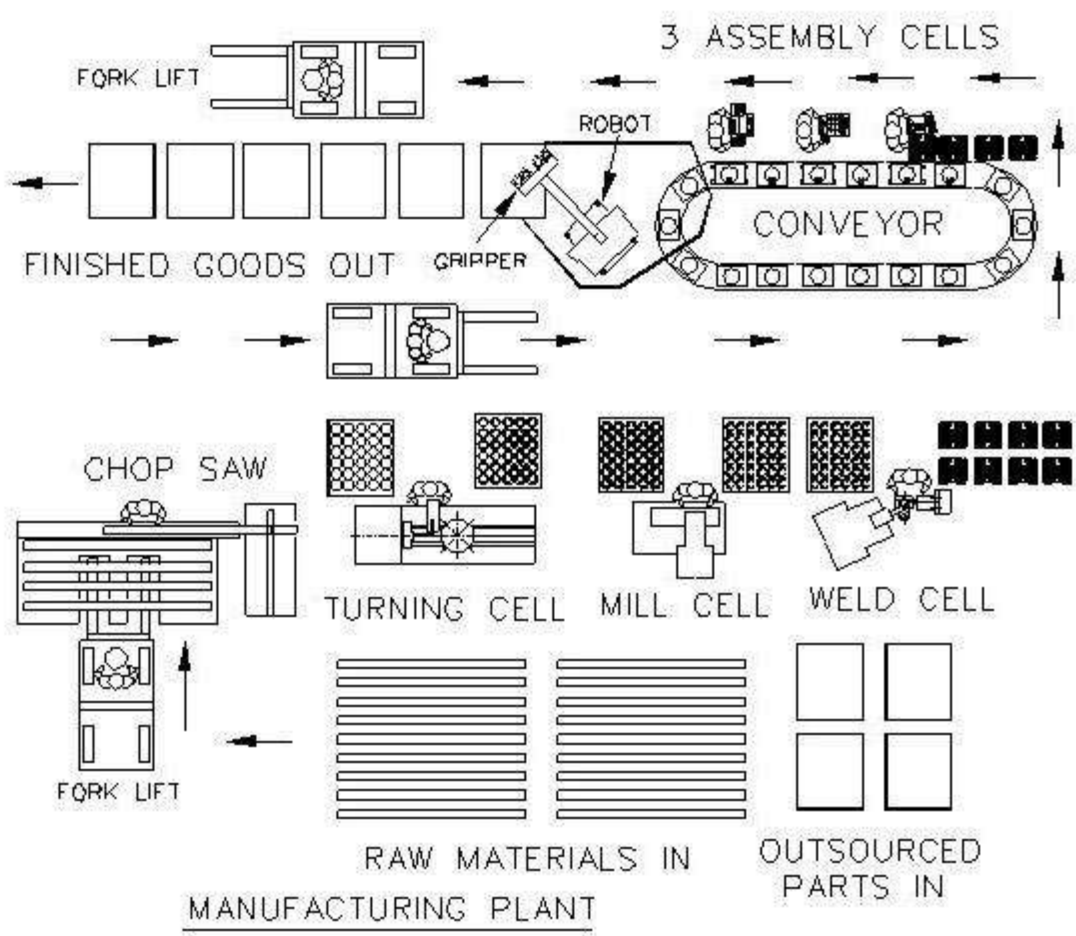
Transfer - Finished product on pallets, usually by fork-lift truck, to a warehouse.

Warehouse - Finished products on pre-defined storage shelve locations.

Inspect / Document - All finished product items at the shipping dock.

Shipping - Packaged products to distributors / customers.

Servicing - Returned products are repaired or replaced.



Typical Manufacturing Facility

The equipment in the semi-automated factory above was planned for the manufacturing of the gearbox shown below.

The human operators make this system flexible. Product model and manufacturing changes can be accommodated quickly. Most changes will incur a cost in; time, materials, and labor.

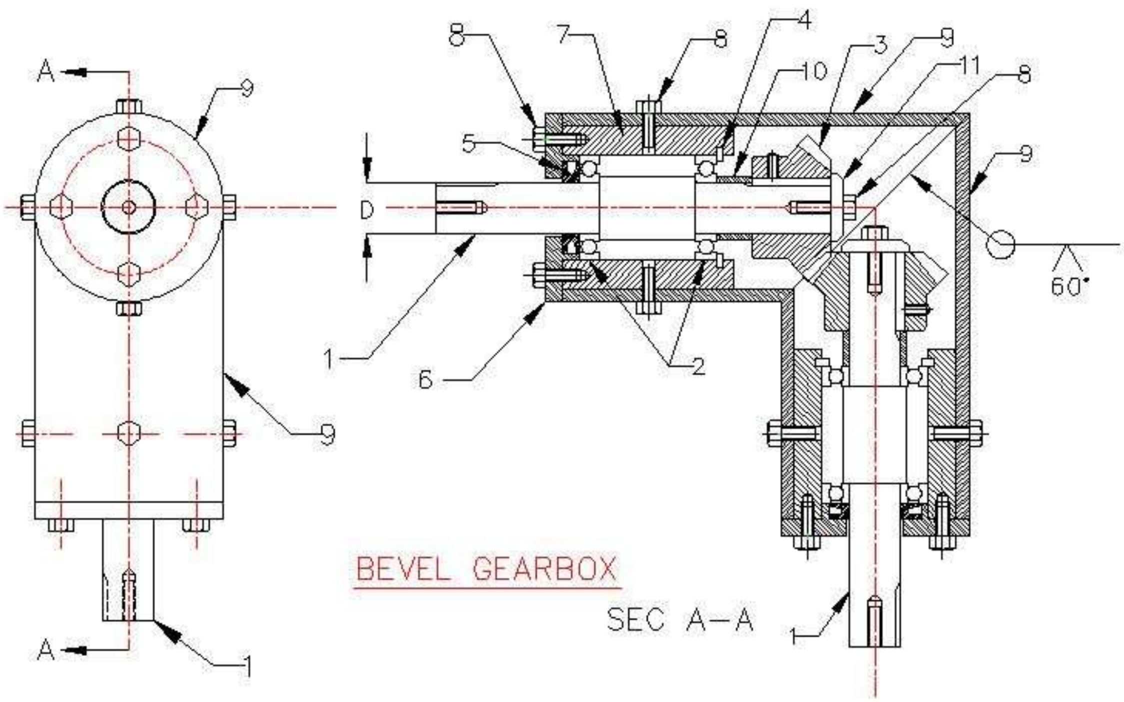
The turning, milling, and welding machines are automatic CNC controlled but require operators to load work-pieces and unload finished parts.

Operator controlled fork lift trucks move pallet loads of parts from cell to cell.

The 3 assembly cells at the top have trays of parts delivered by conveyors but assembly, in special clamps and fixtures, is manual.

Finished product is placed on pallets by a pick and place robot.

The biggest challenge is to create a fully automated robotic manufacturing system with few or no human operators, that is flexible and can accommodate small batches of differing product models at a profit.

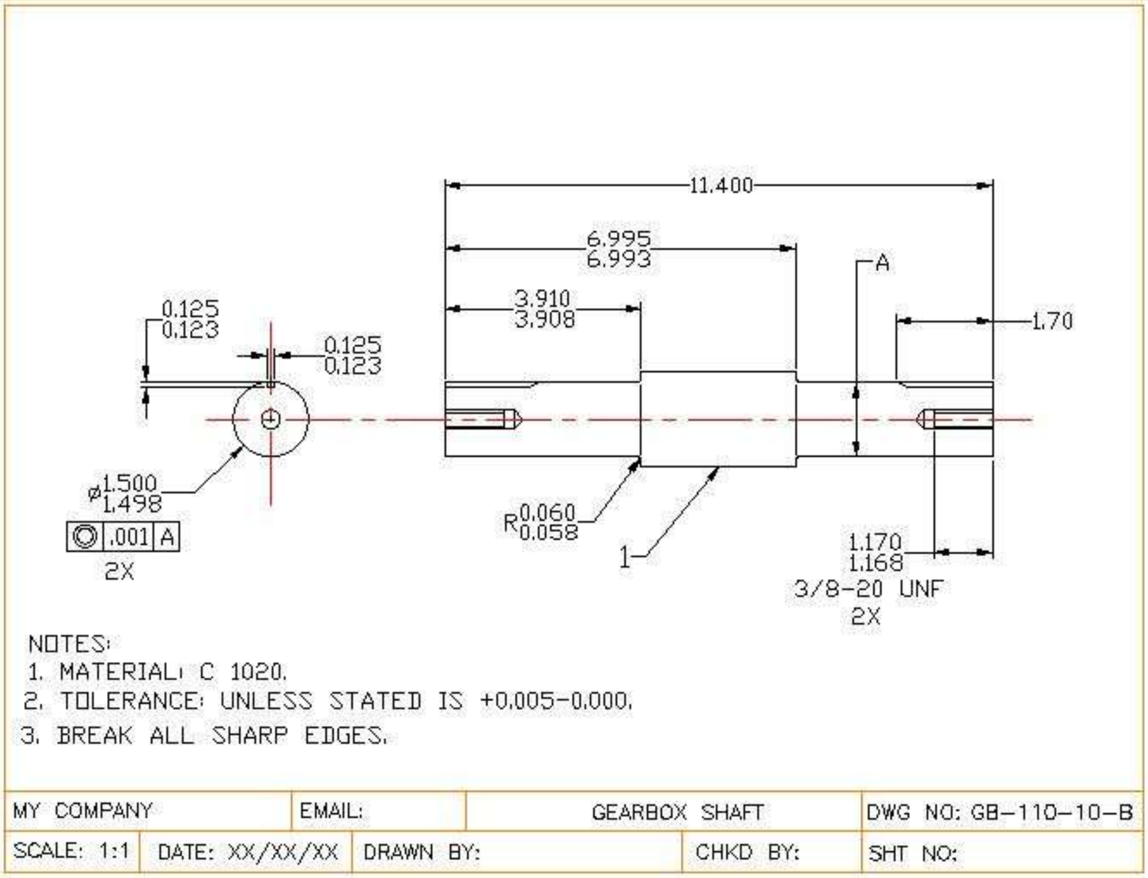


GEARBOX GB-110-C BILL OF MATERIALS			
ITEM	**QTY**	**PART No.**	**DESCRIPTION**
1	2	**GB-110-1-B**	SHAFT
2	4	SP-5062324-A	BALL BEARING
3	2	SP-622334-A	BEVEL GEAR
4	2	SP-72324-A	RETAINING RING
5	2	SP-20324-A	SEAL
6	2	**GB-110-15-F**	END PLATE
7	2	**GB-110-16-C**	HOUSING
8	16	SP-1262324-A	MACHINE SCREW
9	1	**GB-110-18-B**	GEARBOX SHELL
10	2	**GB-110-19-A**	SPACER
11	2	SP-92234-A	WASHER

Gearbox Example

The above bill of materials and the Gearbox Assembly drawing above are the basis of the production planning and tracking system. The parts made in-house are bold type and outsourced and standard parts, which are readily available off-the-shelf items, are given SP numbers.

Bar codes tags are printed and attached to incoming raw materials and follow the transformation process at every stage in the manufacturing process.



Part Drawings

A drawing is made of each part of the gearbox assembly. The shaft drawing shown here is used to plan the machine cells and tooling required to manufacture this part.

Product Performance

1. The horsepower and rotational speed transmitted by the gearbox is limited by the shear strength of the above shaft material which is 8,000 psi.

2. A 20 hp motor turning at 80 rpm will apply; 5251 x 20 hp / 80 rpm = 1330 in-lbs of torque to the shaft.

3. The torque shock & fatigue factor K1 is 3.0 and the keyway stress factor K2 is 1.33.

Shaft Shear Stress = K1 x K2 x Torque / (6.284 x D^3 / 32)

= 3.0 x 1.33 x 1330 / (6.284 x 1.500^3 / 32) = 8,000 psi

The rated torque of the gearbox is 1330 in-lbs which will causes the strength limiting stress of 8,000 psi in the shaft.

This gearbox may be offered for sale for applications up to 20 hp but not for higher power transmission.

Automating Industry Challenge

The demand for all products change over time because of: market trends, new technologies, competition, and for many reasons.

Example: The sales department received an order for 50 gearboxes that must transmit 30 horsepower. That is 50% more than the rated 20 hp capacity.

Repeating the strength calculation above we find that a 1.710 inch diameter shaft is required for 30 hp. Note, 1.750 inch diameter is the nearest standard size of shafts and bearings.

All parts in of the gearbox must be changed except the machine screws and washers.

The cost of changing product drawings, materials, tooling, labor, production and quality control methods to manufacture 30 hp gearboxes must be estimated.

The cost of interrupting the existing manufacturing system must be also be added to the total cost of the change.

Even small changes to existing products are difficult, time consuming, and costly to accommodate in an automated factory, as illustrated above.

Manual Vs Automated Manufacturing

Manual System: Order new raw materials and the existing machine tool operators and assembly workers will make 50 new model gearboxes using the existing factory layout and equipment.

Automated System:
1. Order new raw materials.
2. Order new custom designed grippers for existing machine tool cell and assembly robots.
3. Re-program all robots.

4. Order new jigs and fixtures for all machine tool cells.
5. Order new fixtures for all assembly cells.

Summary: It is obvious that a fully automated manufacturing system is not as flexible as a manual one.

Using today's technology, only mass production over an extend period of time can justify a completely automated system.

State of the Art Product Flexibility

Planes, cars, clothing, etc. can be custom made one at a time but obviously at a price much higher than the mass produced versions. Here are some examples of special purpose automation available today:

1. Milling and turning machine tools are available with automatic tool changers. For example: a 0.500 diameter drill bit and chuck can be replaced by a 0.750 diameter drill bit and chuck at the command of a computer at any time in a machining cycle without human intervention.

2. Automatic real time quality control is also in operation in state of the art manufacturing facilities. Pneumatic and laser sensors can measure parts to an accuracy of 0.0005 inches during machining operations. For example; a shaft is found to be 0.001 inches oversize. This data is sensed by a laser and is transmitted to the computer controlled lathe. The cutting tool is moved 0.001 inches closer to the shaft center automatically to bring following parts back into specification.

3. Product drawings are changed automatically with parametric computed aided design (CAD) systems. New part and assembly dimensions and bills of material are adjusted to create new product model drawings automatically. This digital data are networked to computer numerically controlled (CNC) machine tools that make the new model parts having new dimensions.

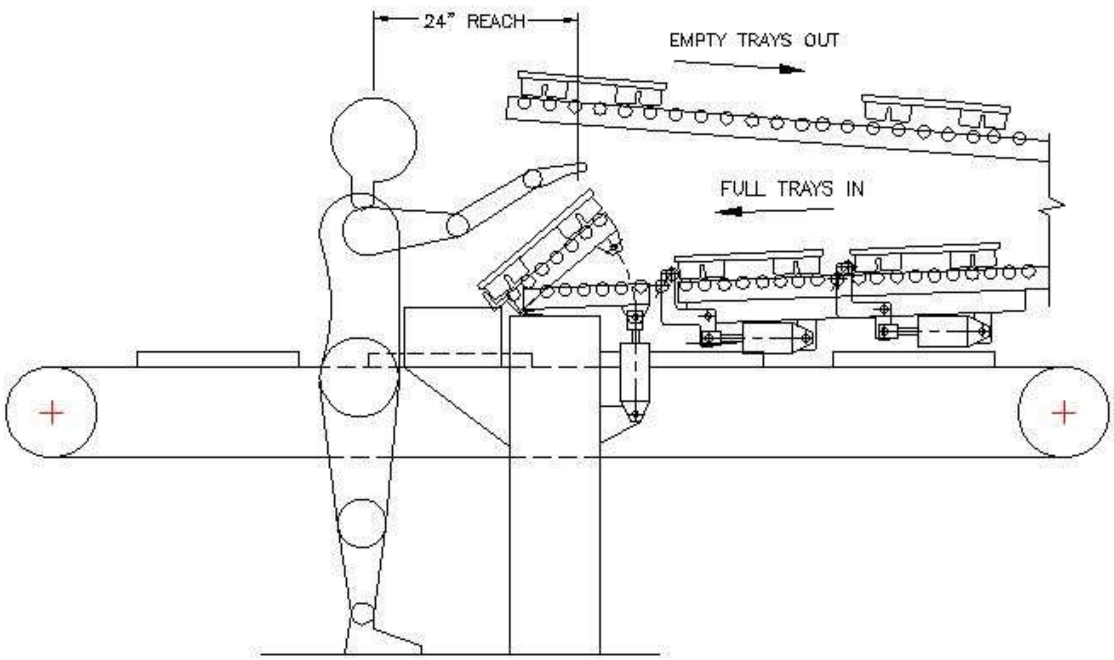
4. It is possible today to order a custom built personal computer online and have it delivered in a short time.

5. You can walk into an automobile dealership show room and order a car with a wide range of custom features on the internet a get fast delivery. Your custom car will join hundreds of other cars in the existing assembly line. The special engine, sound system, GPS map, upholstery, color scheme, etc. will be installed at predetermined assembly cells.

6. The paint department in many home improvement stores can closely match any solid color swatch presented and mix a small batch of the paint while you wait.

7. Many houses and buildings are custom designed and built at a construction site.

8. Individual modular buildings are built to unique specifications in a factory.



ASSEMBLY CELL–1 SIDE VIEW

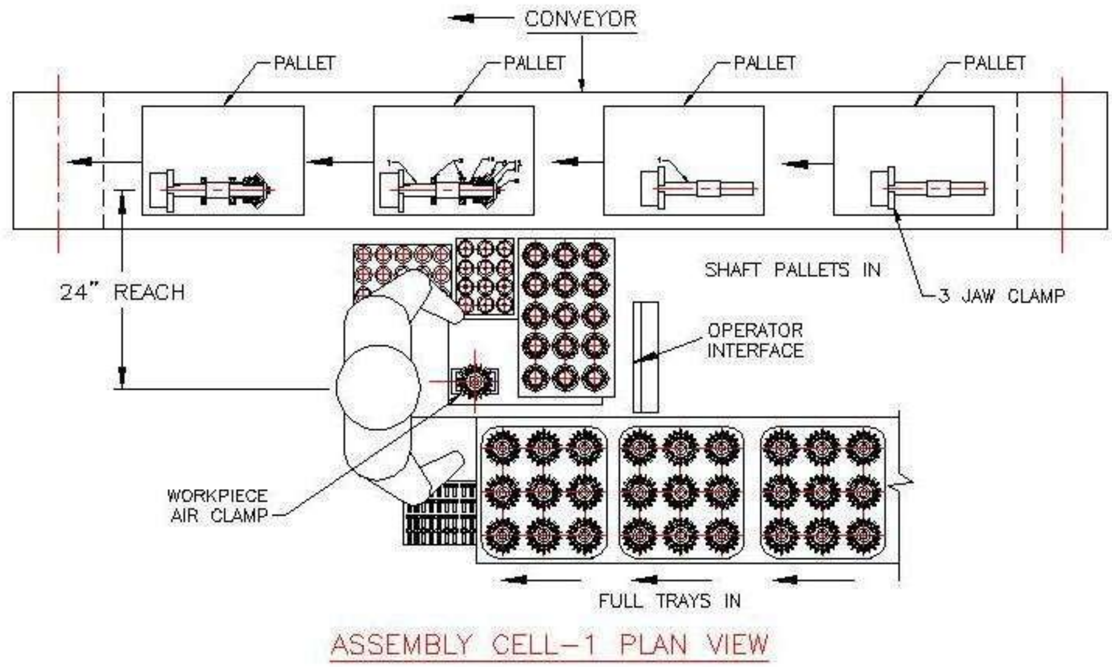
A side view of an assembly cell for the above gearbox is shown above.

Trays filled with gearbox parts move toward the operator on a roller conveyor.

One forklift truck operator can deliver palette and tray loads of raw materials and parts to all machine tool and assembly cells in the factory layout shown above.

The tray at the work station is tilted up, by an air cylinder, for easy accesses.

Empty trays move away from the operator on the upper roller conveyor.



The plan view of the above assembly cell is illustrated here.

1. A shaft is clamped on each conveyor pallet.
2. A shaft is removed, clamped in a fixture, and items are assembled.
3. The operator then replaces the shaft subassembly on the empty palette.
4. The conveyor moves one pallet distance to the left at a fixed cycle time.
5. The assembly line stops when the operator presses a foot switch.

GET OBJECT	
10"	0.50 SEC
20 '	0.75 SEC
30"	1.00 SEC
GRASP	0.50 SEC
MOVE OBJECT	
10"	0.50 SEC
20"	0.75 SEC
30"	1.00 SEC
PLACE OBJECT	0.75 SEC
POSITION OBJECT	1.00 SEC
WITHDRAW HAND	
10"	0.50 SEC
20"	0.75 SEC
30"	1.00 SEC

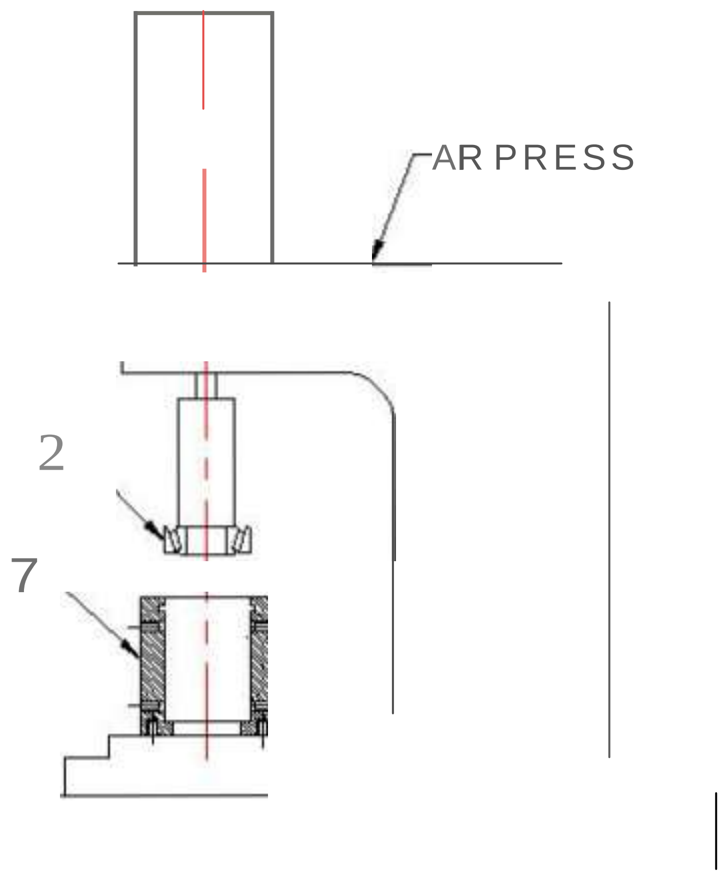
Manuel Time and Motion

Typical manual operation times are listed above.

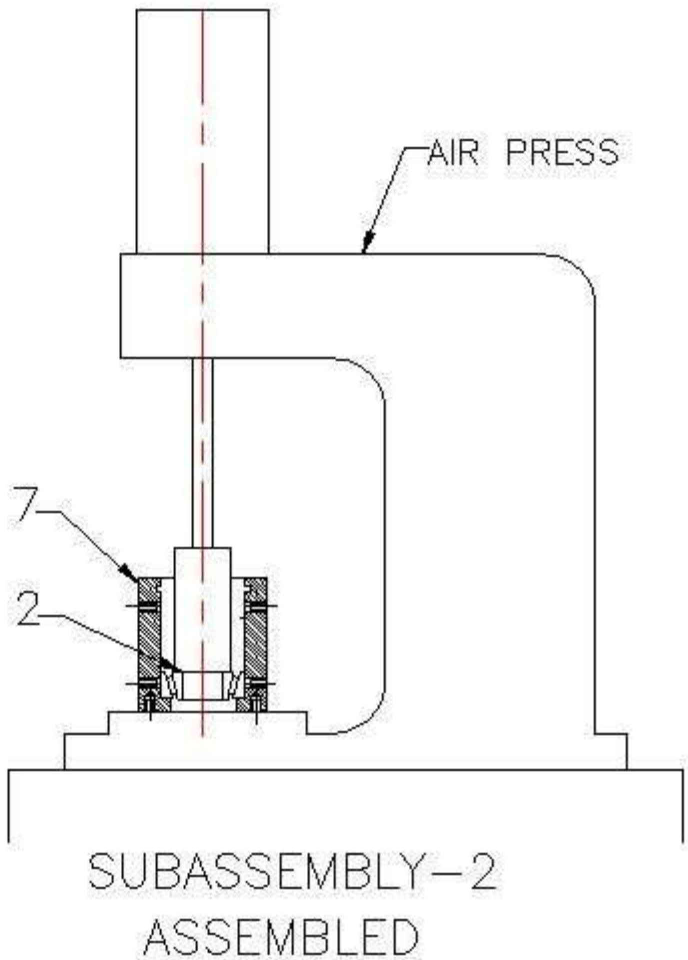
A robot assembly cell similar to the one below can perform the same as the manual assembly cell above.

The two vibrating bowel feeders in the foreground deliver small parts to pick and place robots in the above automated assembly cell.

More can be found at the “Evana Automation” home page.



SUBASSEMBLY-2 ASSEMBLING



ASSEMBLY LINE TIME BALANCE.

Inserting a bearing onto the housing is one subassembly in the complete assembly of the gearbox.

The time to assemble each subassembly of the gearbox, in the assembly line, must be equal for maximum efficiency.

Cell assembly time includes the time to convey the parts to the assembly cell and assemble them.

If the time to complete each subassembly is the same, the system is said to be "balanced" and the assembly line is operating at maximum efficiency.

Example 1:
The planned production rate is to be 600 units per 7 hour day.

The cycle time for each machine tool and assembly cell is:

Cycle time = Units / Time = 600 / (7 x 60) = 1.43 units per minute

Example 2:
There are 3 subassembly cells; A, B, and C requiring the following cycle times;

A = 1 minute, B = 2 minutes, and C = 3 minutes.

Cell A is idle 2 minutes and cell B is idle 1 minute out of every three minutes.

Cell A, B, and C product one unit per 3 minutes.

That is 60 mins / 3 mins per unit = 20 per hour.

Total output of task times = 20 per hour

Average cycle time = (1 + 2 + 3) / 3 = 2 minutes.

The objective is to balance cell times at the average cycle time value:

Cell A output needs to be = 1 per 2 mins

Cell B output needs to be = 1 per 2 mins

Cell C output needs to be = 1 per 2 mins

Cell A, B, and C product one unit per 2 minutes.

That is 60 mins / 2 mins per unit = 30 per hour.

Input of average task times = 30 per hour.

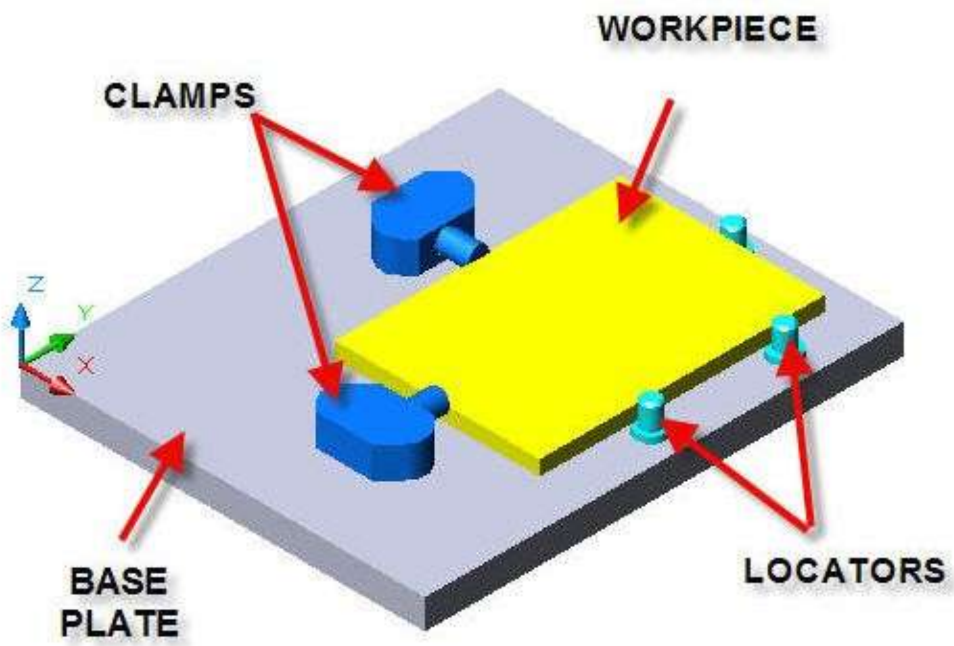
Efficiency = Total output of task times / Input of average task times

= 20 / 30 = 67%

Example 3:
If some of the work done by cell C is shifted to cell A so that each of the three cells has a cycle time of 2 minutes, the efficiency will be improved.

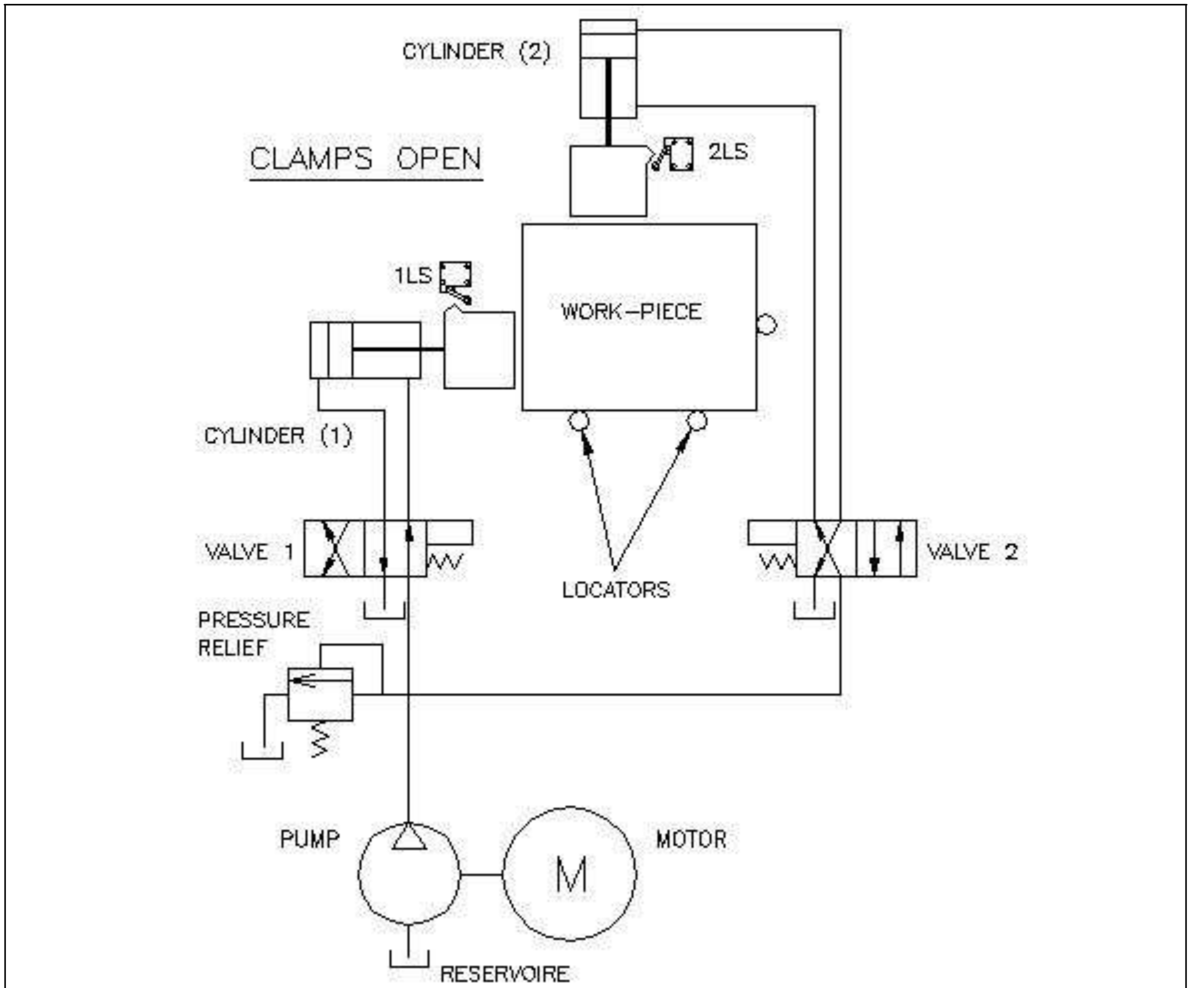
The number of widgets assembled in Example 1 is, 1 per 3 minutes or 60 /3 = 20 per hour.

The number of widgets assembled in Example 2 is, 1 per 2 minutes or 60 /2 = 30 per hour, a 50% increase in production.



A metal plate moved from a transfer conveyor to a computer numerically controlled (CNC) milling machine table base plate.

Automatic clamping of the above work-piece is accomplished with the hydraulic circuit shown below.

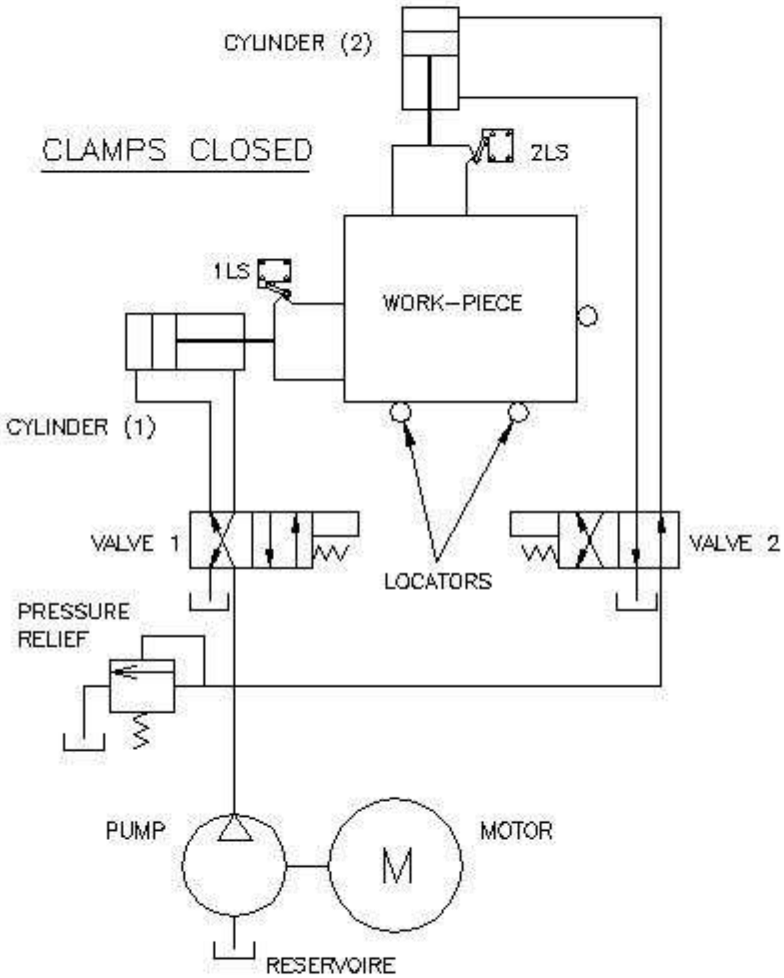


The motor drives the hydraulic pump.

A signal from an electronic controller shifts valves 1 and 2 to the retract position shown above.

Hydraulic fluid causes cylinders 1 and 2 to retract.

Excess fluid is returned to the reservoir through the pressure relief valve.



A signal from an electronic controller shifts valves 1 and 2 to the extend position. Cylinders 1 and 2 clamp the work-piece against the three locators.

Reliability

The system above is a typical industrial automated clamping fixture.

There are a many mechanical and electronic components in this and every automated production system.

Due to the inevitable complexity, maintenance is high and reliability is low.

<u>Every electronic request for an action must be verified by an independent electronic signal to the controlling unit.</u>

Preventive maintenance of all manufacturing equipment at regular intervals is required.

Attempts have been made to automate maintenance with limited success. Lubrication for example has been applied periodically and in response to temperature variations automatically.

Replacing worn gears, bearings, shafts, seals, and other parts automatically will be difficult to do automatically and cost effectively.

Computers and programmable controllers provide control of automated production systems. A state of the art control system will include:

1. Color graphic display monitor called a "Human Machine Interface" (HMI).

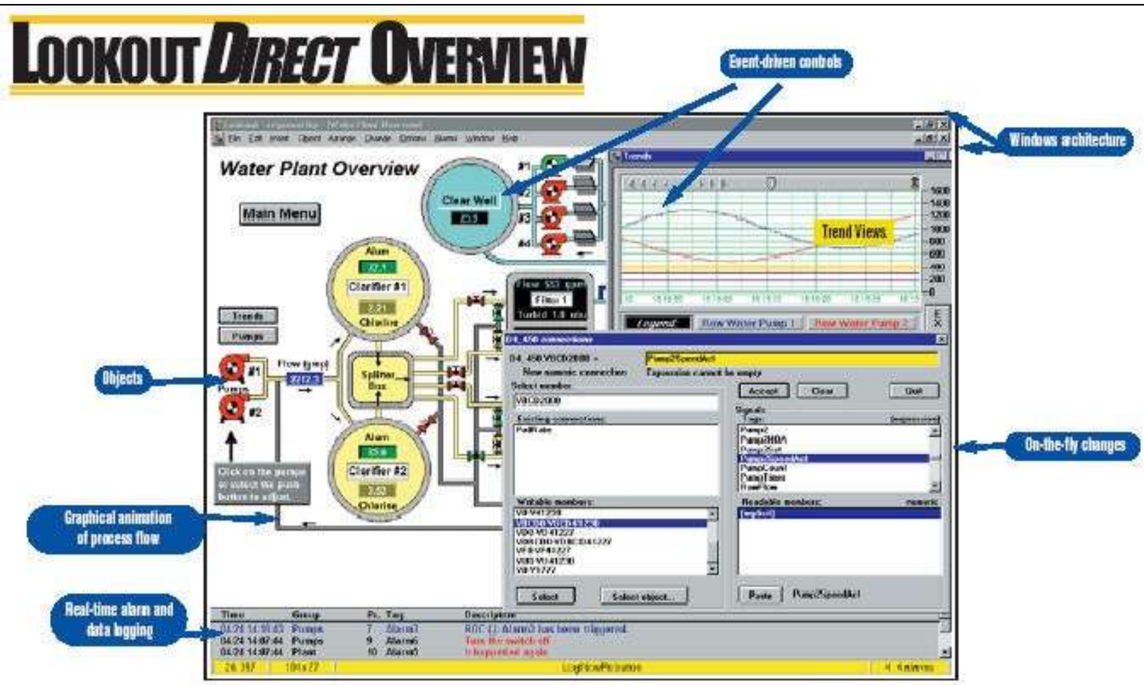
Easy to create 3-D animated display of all processes in each machine or assembly cell.

Multiple windows with live display of product quality parameters.

2. Touch screen, mouse, and keypad control.

Convenient control system changes.

3. User friendly Programmable Logic Controller (PLC) language.



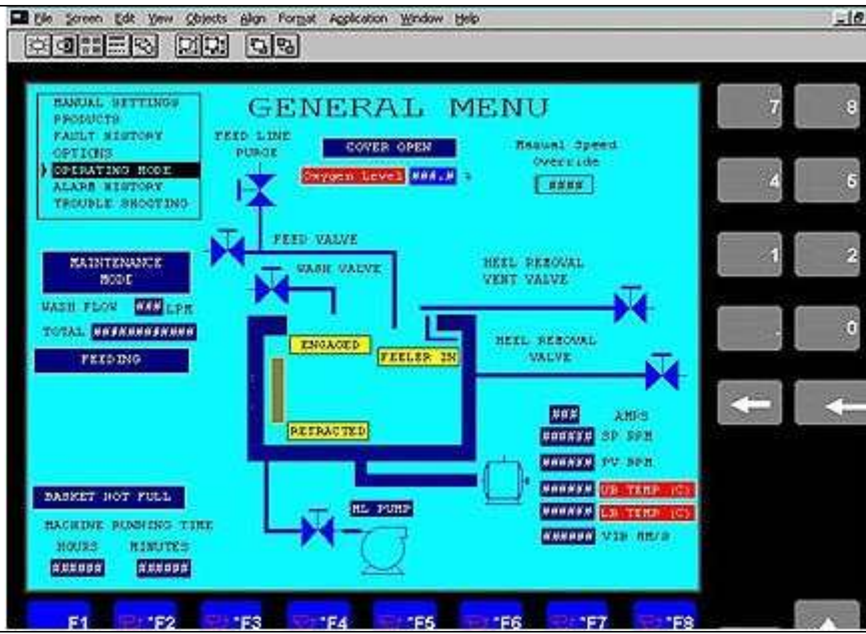
See www.automationdirect.com for more information about event driven control systems.

Lookout Direct has an event driven control system.

Each sensor, limit switch, or other gage remains in its current state until an event occurs.

Up to 25,000 trend values can be transmitted per second.

Ladder logic controllers must cycle through all steps in the ladder logic before returning for another cycle. This may take too much time.



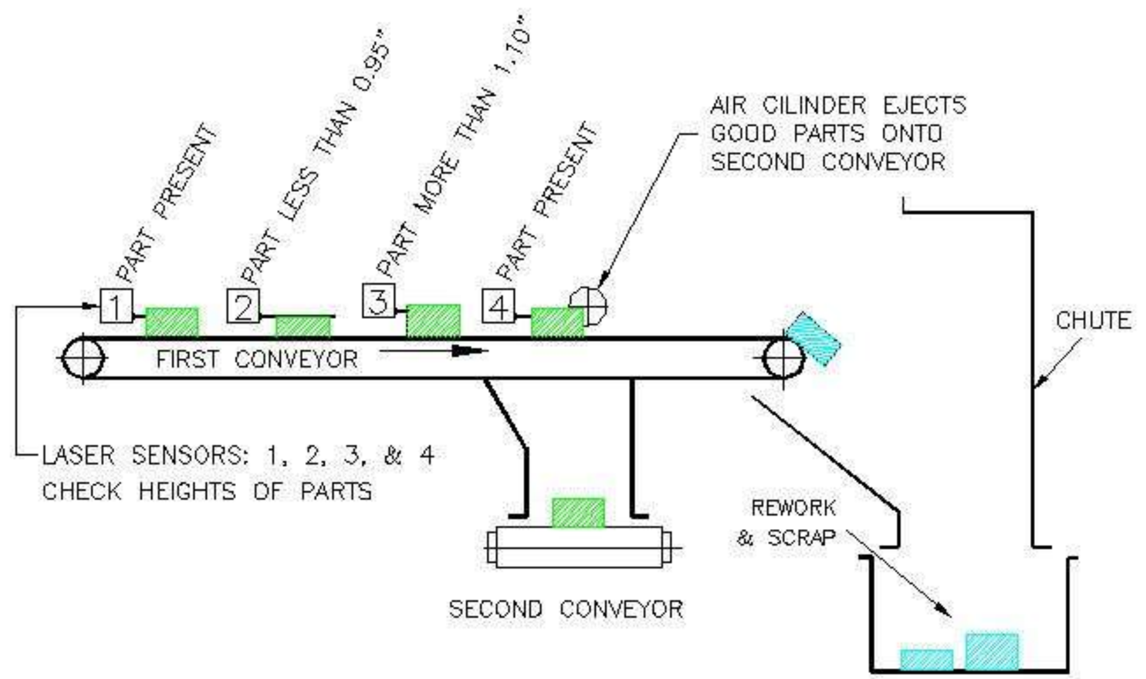
For more information about the Human-Machine-Interface shown above see www.rousselet-robatel.com

CONVEYOR CONTROLS

The Programmable Logic Controller (PLC) is a special purpose computer for controlling many industrial manufacturing processes. General purpose personal computers are also used to work with PLC's or independently, to perform the same tasks. A step-by step sequence of operations is written in English.

A "Ladder Logic Diagram" is written in special purpose computer software, to represent the series of electrical controls.

"Input" and "Output" signals. A manual push button starts the motor driven conveyor. Then a laser sensor detects that a part is present and a green light is turned on, a clamp grips the part, a pick and place arm removes the part from the conveyor and places it into a box, and so on through the manufacturing process. This Ladder Logic Diagram is typed into computer memory in the form a Program that can be used to operate many electrical devices repeatedly many thousands of times. Here we use a conveyor control program where good parts between 0.90 and 1.10 inches high are separated from bad parts automatically as an example shown below:



OPERATING SEQUENCE

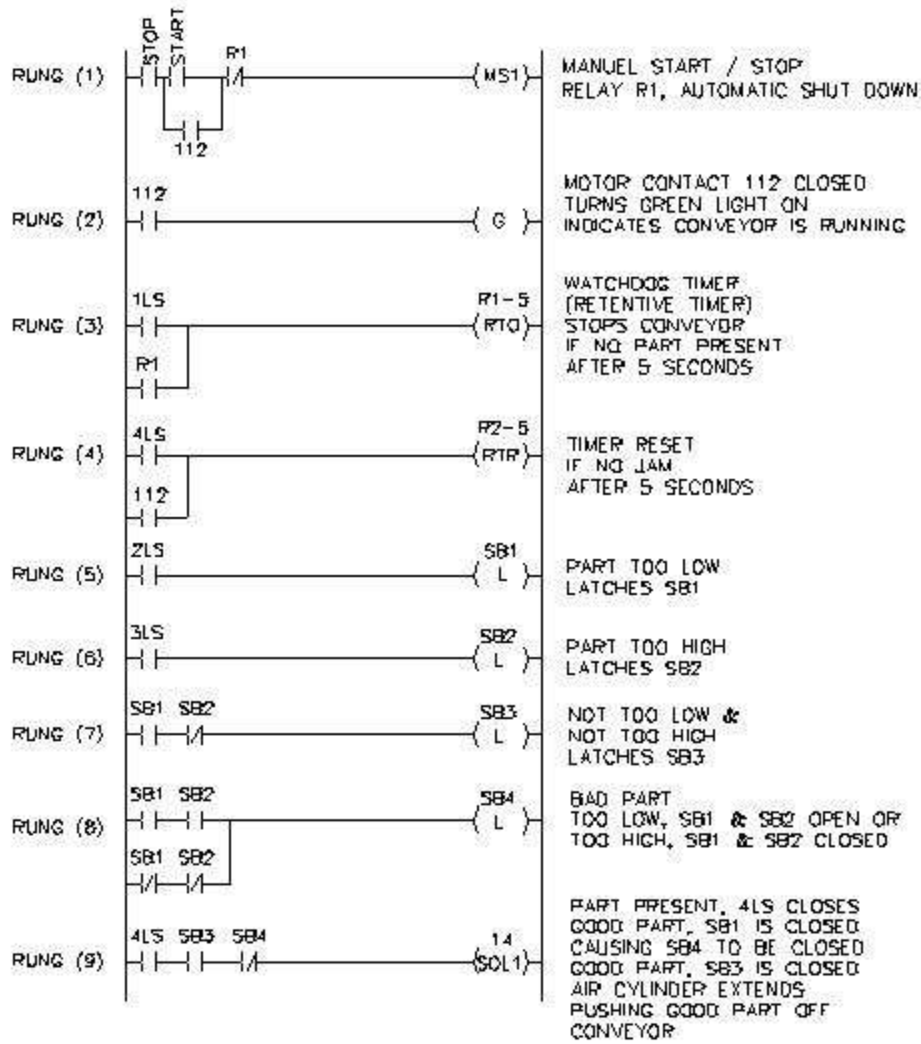
1. Operator starts the conveyor.
2. Green light on indicates conveyor is running.
3. Laser sensor (1) detects that a part is present.
4. Laser sensor (2) detects that the part is less than 0.90 inches high.

5. Laser sensor (3) detects that the part is more than 1.10 inches high.

6. Laser sensor (4) detects that a good part has arrived.

7. An air cylinder extends if a good part has arrived and pushes it onto the next conveyor.

8. Parts that are either too high or too low fall off the end of the conveyor into a bin to be inspected whether to scrap or rework.



LADDER LOGIC DIAGRAM

A Ladder Logic Diagram resembles a ladder in which each rung has input devices on the left and output devices on the right side.

Rung (1) This rung provides manual conveyor motor (Start) and (Stop)

Switches. Also part jam and automatic shut down (50).

Rung (2) The auxiliary contact of the motor starter (112) is monitored to provide a conveyor run indicator (14).

Rung (3) Watchdog Timer, Laser sensor (1LS) enables (turns on) a Retentive Timer (RTO) which is latched by the timer Enable bit (50). A jam condition is detected if the Timer times out.

Rung (4) Laser sensor (4LS) or the Start push button (112) resets the timer. If reset prior to 5 seconds, no jam has occurred.

Rung (5) A part passing (2LS) [Part too low] latches (SB1) if the part height is less than 0.90 inches.

Rung (6) A part passing (3LS) [Part too high] latches (SB2) if the part height

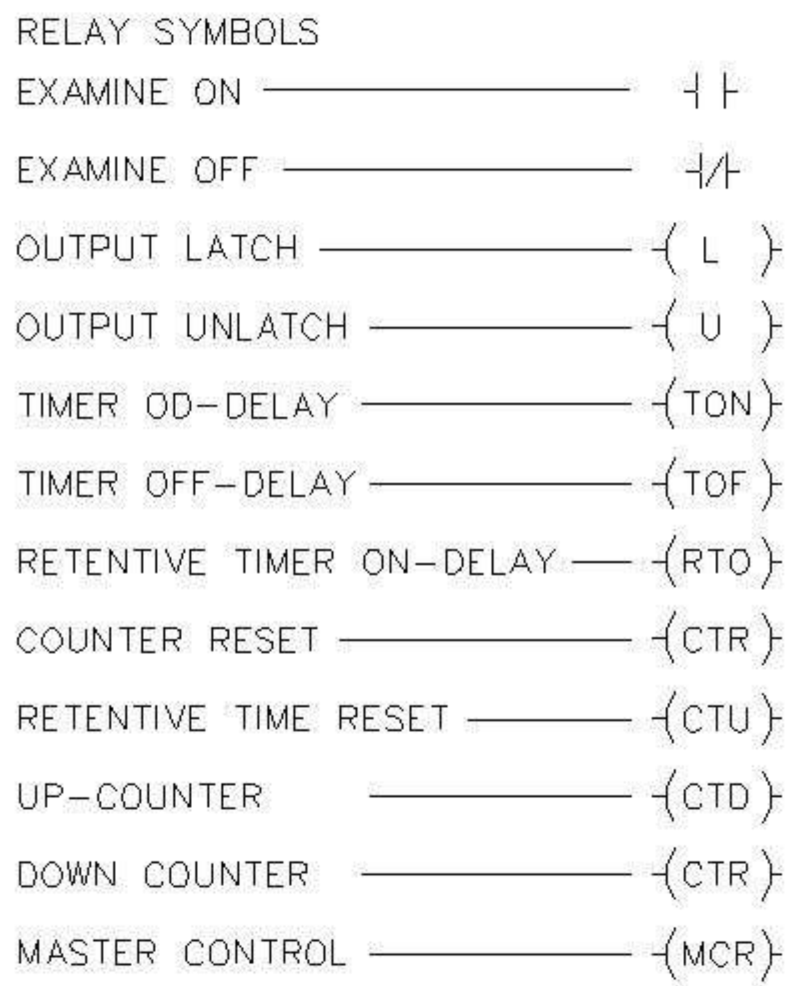
is greater than 1.10 inches. (SB2) remains unlatched if the height is less than 1.10 inches.

Rung (7) A part between the tolerance range 0.90 and 1.10 inches latches (SB3). (2LS) closes latching (SB1), but (3LS) does not close.

Rung (8) A part out of tolerance latches (SB4) sending the part into the bad

part bin. (2LS) & (3LS) both close because the part is too tall or both (2LS) & (3LS) do not close because the part is too short.

Rung (9) A good part at (4LS) actuates Solenoid (SOL1) and the air cylinder extends pushing the part onto the next conveyor. Timer (1LS) has not timed out and part is not too short (SB1) and not too tall (SB2).



CONTROL SYSTEM COMPONENTS

A Control System includes the PLC or PC System, programs, and all Input / Output devices that are used to control or obtain feedback from the controlled system.

PLC Programmable Logic Controller.

PC Personal Computer, with “Flow Chart Logic” software, may be used in place of the PLC.

Program The list of instructions (in the form of a ladder diagram) that tell the PLC the sequence of control actions to be carried out in response to input signals.

Flow Chart Logic A sequence of instructions (in the form of a flow chart) that tells a PC the sequence of control actions to be carried out in response to input

signals.
Eliminates the need for ladder logic diagrams.

Output The signal sent from the PLC or PC, to the external device.

Output device An external device that receives signals from the PLC.

Output devices Motor
Stepper Motor
Clutch
Brake
Air Cylinder Valve
Hydraulic Cylinder Valve

Ladder diagram Electric circuit symbols arranged on the rungs of a ladder with inputs on the left and outputs on the right..

Input signal Generally an input signal from an external device such as a switch that goes from off to on or other change in status.

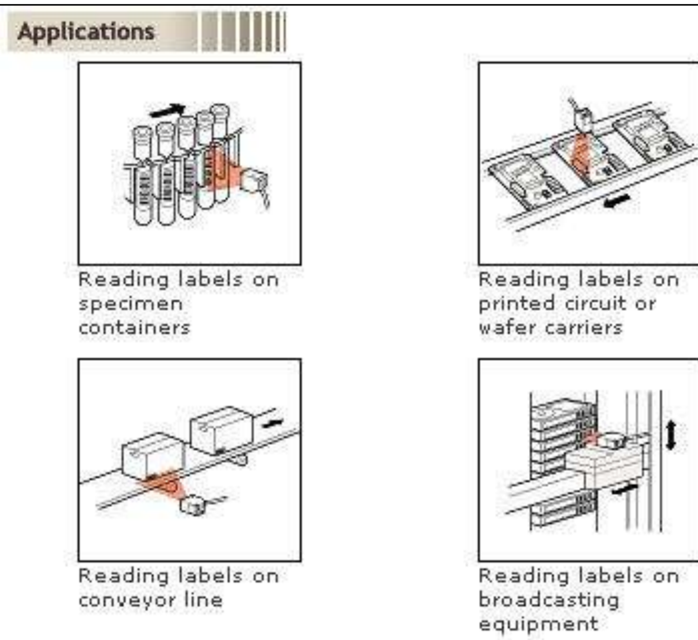
Input devices Bar Code Reader
Limit Switch
Pressure Sensor
Proximity Switch
Position / Angle Transducer
Temperature Sensor
Vision System

Instruction line A group of conditions that lie together on the same horizontal line of a ladder diagram.

Instruction block Instruction lines that branch apart or join together in the ladder diagram.

The Keyence bar code reader is illustrated above and applications of its use are below.

More information can be found at:
http://world.keyence.com/bar_code_readers/bl_500/bl_500.html

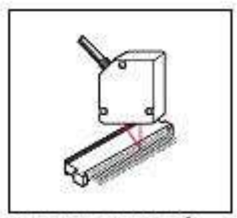


One of many Keyence laser sensors is illustrated above and applications of its use are below.

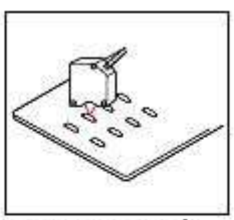
More information can be found at: www.world.keyence.com

Applications

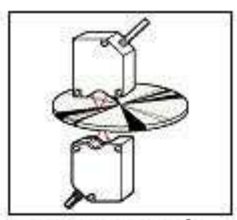
Measurement of CD pickup travel



Measurement of pin pitch and alignment



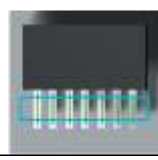
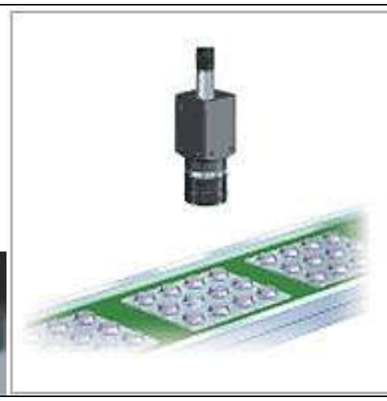
Measurement of solder paste height on PC boards



Measurement of silicon wafer thickness

A Keyence digital vision system is illustrated above and applications of its use are below.

More information can be found at: www.world.keyence.com

The Keyence vision system above left is checking the dimensions between chip pin centers. Right objects are counted.

See full-size image.
www.assemblyandautomationtech.com/Images/scre...
135 x 180 pixels - 35k
Image may be scaled down and subject to copyright.

original context on the page: **www.assemblyandautomationtech.com/standard.html**

The spiral stepped bowel above vibrates rapidly at small amplitude. Screws, bolts, or other small parts move up and around to the top where they are orientated and slide down the chute into the automatic screwdriver or other assembly unit.

Find more information at: www.assemblyandautomation.com

See full-size image.
www.designtoolinc.com/home1.jpg
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original context on the page: **www.designtoolinc.com/**

More information about the vibrating bowel part feeder above can be found at: www.designtoolinc.com

Robots are used in many manufacturing applications, including:

Painting + Welding + Picking and Placing + Sealing + Assembling.

Advanced Automation at: http://www.aautomation.com/
"Advanced Automation designs, manufactures and integrates custom automation systems and highly specialized machinery for process and product development and manufacturing applications. Advanced Automation has the ability to pull from a diverse and extensive library of automated technologies for assembly, material handling, testing and inspection, packaging, metal processing and other one-of-a-kind applications.

Keyence; Laser sensors, vision system are at: http://world.keyence.com
" Fastest in its class
Ultra-high-speed processing of 20,000 parts/min
· Digital image transfer
· Repeatability of ±0.05 pixels
· On-screen statistical data processing"

DeStaco Automation equipment can be found at:
http://www.destaco.com/index.asp?site=7

Robohand Pick and Place Equipment is at: www.fusebox.com/Robohand/

Challenge:

Specialty Automation: Simple Assembly Upgrade Yields 257% Productivity Increase Specialty Automation was asked by their Automotive customer to build a machine to assemble door jamb switches. They needed a gripper that could handle circular parts to be placed within a +/- .002 inch precision requirement. For past requests, fifteen workers were used to do the assembly manually.

Solution:

Robohand, A DE-STA-CO Industries Company, designed a simple pick and place process using the model RPC-315 parallel gripper, and models DLT-12-L for the Y axis and DLT-16-L for the X-axis, externally powered thruster slides. As part of the new process, two plungers are picked up at the same time and placed in the assembly.

Result:

Thanks to Robohand, the new pick and place unit has provided immediate return on investment. In just five days, productivity increased 257%, from 8400 pieces per day on one shift with fifteen manual laborers to 21600 pieces per day, on one shift with one operator. Production almost tripled per shift. The job is done with precision, consistently each time.

Electric Servo-Driven Robot suits high speed manufacturing.

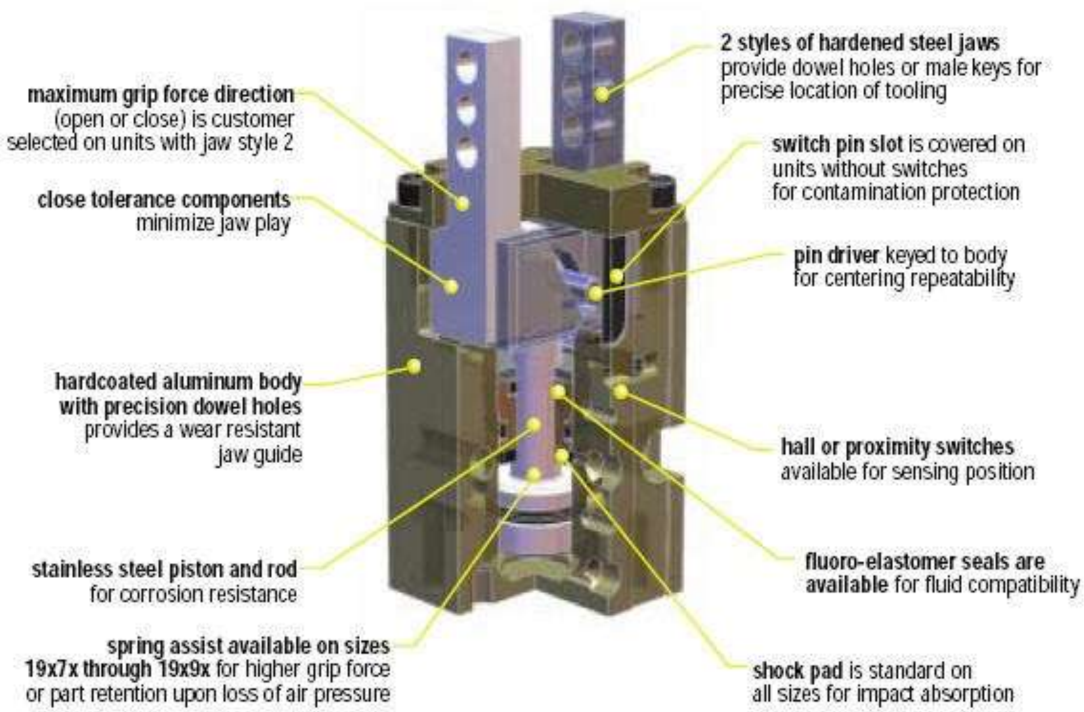
July 22, 2002 - Model M-420iA four-axis, modular construction robot has 40-kg payload and remote mechanical and control unit. It palletizes 48 x 40 in. pallets at heights to 40 in. Model M-421iA (two-axis variant of M-420iA) does not include waist and wrist axes, and handles payloads to 50 kg. Each model includes PalletTool off-line pallet creation software. PalletPRO palletizing simulation software verifies system throughput, robot reach, cell interference, and pallet configuration.

See full-size image.
news.thomasnet.com/ images/large/2002/07/12069.jpg
644 x 441 pixels - 191k
Image may be scaled down and subject to copyright.

original context on the page: **news.thomasnet.com/ fullstory/12069**

The information below, about pick and place grippers, was obtained from: www.phdinc.com.

"PHD is a leading manufacturer of pneumatic and hydraulic industrial automation actuators, designed to help companies across all industries optimize their manufacturing processes. Our products consist of a full line of **hydraulic and pneumatic cylinders, escapements, grippers, linear slides, rotary actuators, clamps, multi-motion actuators, switches and sensors."**



Product Specifications

SPECIFICATIONS	SERIES 190 & 191
OPERATING PRESSURE	30 psi min to 150 psi max [2 bar min to 10 bar max] air
OPERATING TEMPERATURE	-20° to +180°F [-28° to +82°C]
RATED LIFE	10 million cycles minimum with standard seals (including spring assist units)
GRIP REPEATABILITY	Within ±0.002 [±0.05 mm] of original centered position
LUBRICATION	Factory lubricated for rated life
MAINTENANCE	Field repairable

GRIPPER NO.	DISPLACEMENT		GRIPPER WEIGHT STANDARD		GRIPPER WEIGHT SPRING ASSIST		GRIP FORCE FACTOR G_F MAX. DIRECTION		GRIP FORCE FACTOR G_F MIN. DIRECTION		SPRING ASSIST GRIP FORCE S_F	
	in³	cm³	lb	kg	oz	g	Imperial*	Metric*	Imperial	Metric	Imperial	Metric
19x60 & 19x65	.012	0.2	0.11	0.05	—	—	.061	3.93	.049	3.16	—	—
19x61 & 19x66	.012	0.2	0.11	0.05	—	—	.061	3.93	.049	3.16	—	—
19x62 & 19x67	.012	0.2	0.13	0.06	—	—	.037	2.39	.029	1.87	—	—
19x70 & 19x75	.036	0.6	0.24	0.11	0.26	0.12	.122	7.87	.092	5.93	2.230	9.99
19x71 & 19x76	.036	0.6	0.25	0.11	0.26	0.12	.122	7.87	.092	5.93	2.230	9.99
19x72 & 19x77	.036	0.6	0.27	0.12	0.28	0.12	.093	6.00	.069	4.45	1.690	7.57
19x80 & 19x85	.110	1.8	0.64	0.29	0.65	0.29	.250	16.13	.210	13.55	4.280	19.17
19x81 & 19x86	.110	1.8	0.67	0.30	0.68	0.31	.250	16.13	.210	13.55	4.280	19.17
19x82 & 19x87	.110	1.8	0.71	0.32	0.73	0.33	.150	9.68	.130	8.39	2.630	11.78
19x90 & 19x95	.250	4.1	1.44	0.65	1.47	0.67	.490	31.61	.370	23.87	8.700	38.98
19x91 & 19x96	.250	4.1	1.46	0.66	1.48	0.67	.490	31.61	.370	23.87	8.700	38.98
19x92 & 19x97	.250	4.1	1.62	0.73	1.64	0.74	.270	17.42	.200	12.90	4.760	21.32

*Maximum grip force direction is always open (internal grip) on all Series 190 and 191 Jaw Style One units. (19x60, 19x65, 19x70, 19x75, 19x80, 19x85, 19x90, and 19x95)

Need Cv or SCFM calculations for this Actuator?
Click here to download PHD's Cv/SCFM calculator

Need Cv or SCFM calculations for this Actuator?

Click here to download PHD's Cv/SCFM calculator

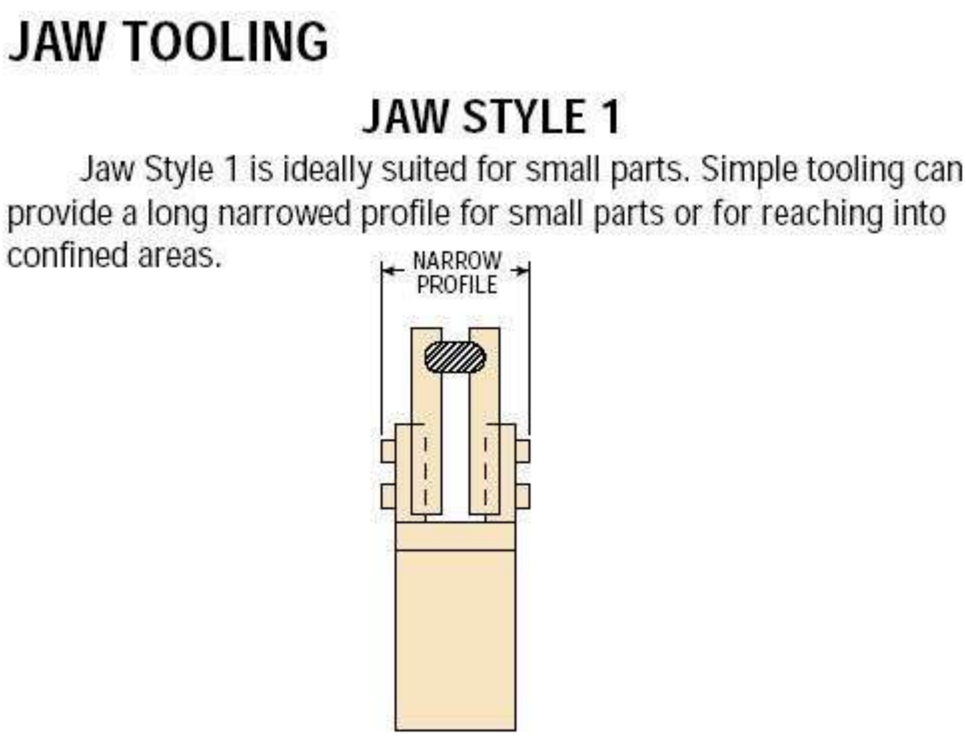
"These hydraulic and pneumatic actuators provide the fundamental motion to **push, pull, lift, rotate, turn, grip, reach, clamp, hold, position, escape, insert, load, unload, pick, place, and orient** parts or materials in your manufacturing processes. Applications include loading/unloading, assembly, packaging, work holding, positioning, material handling, orienting and feeding."

"WHAT IS INDUSTRIAL AUTOMATION ?

Industrial automation can be described as the automatically controlled operation of an apparatus, process, or system by mechanical or electronic devices that replace human control. PHD actuators are typically employed as the building blocks of these machines, systems and devices to provide the required mechanical motion for a wide variety of processes. Applications include **loading/unloading, assembly, packaging, work holding, positioning, material handling, orienting and feeding**."

"PHD's AUTOMATION SOLUTIONS

PHD is a leading manufacturer of industrial automation actuators, designed to help companies across all industries optimize their manufacturing processes. Our products consist of a full line of cylinders, escapements, grippers, linear slides, rotary actuators, clamps, multi-motion actuators, switches and sensors. **These actuators provide the fundamental motion to push, pull, lift, rotate, turn, grip, reach, clamp, hold, position, escape, insert, load, unload, pick, place, and orient parts or materials in your manufacturing processes. Known for robustness, precision, and extremely long life,** PHD products have the attributes and performance design engineers demand."



GRIPPER JAW TOOLING DESIGN PROJECT

The student will use CAD to design the special purpose gripper jaws for the "Jaw Style 1".

1. Study the PHD Gripper data presented here.

2. Go to: www.phdinc.com and study the industrial pick and place videos provided.

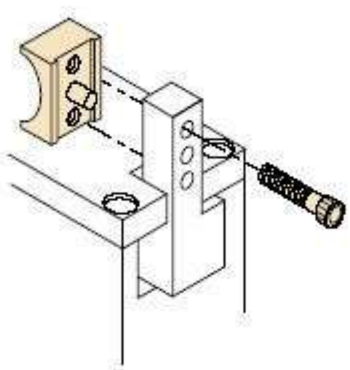
3. Design a pair of gripper tools, for model 19190 parallel griper a that will clamp a 0.50" diameter machine screw standing on its head.

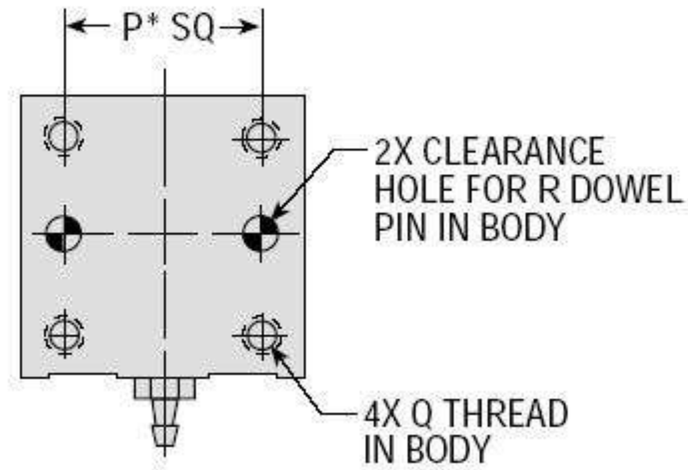
4. Show +/-0.002 upper and lower limit dimensions.

5. Add cylindrical geometric tolerances for the tool faces that grip the bolt.

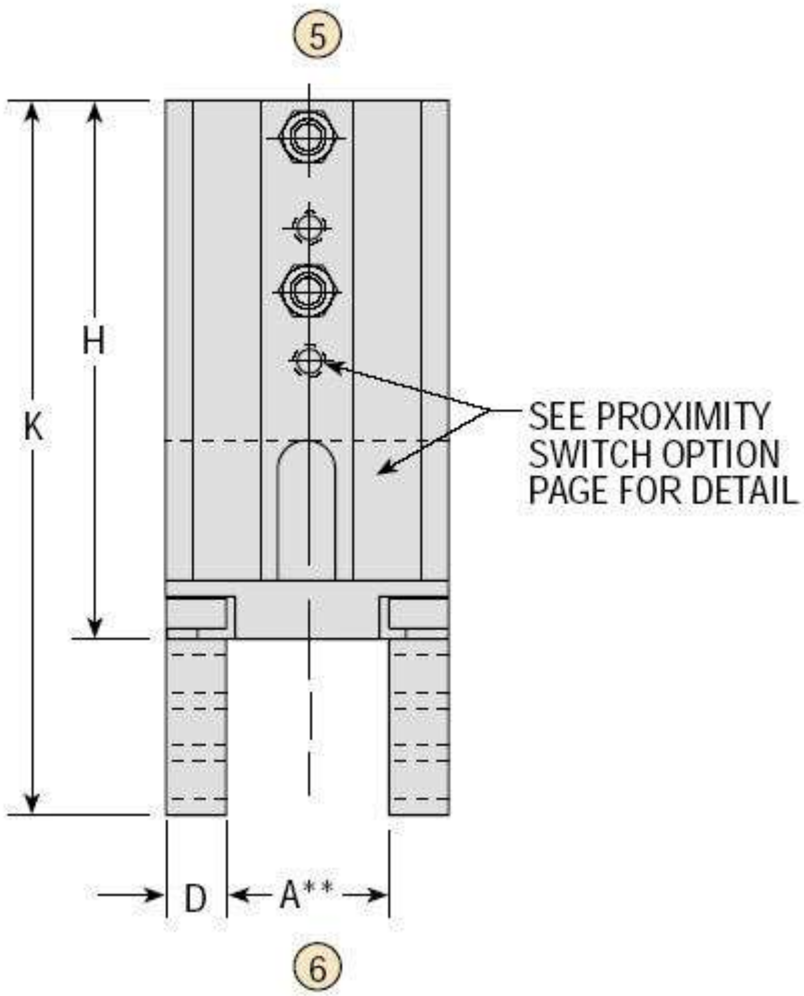
DOWEL PINS

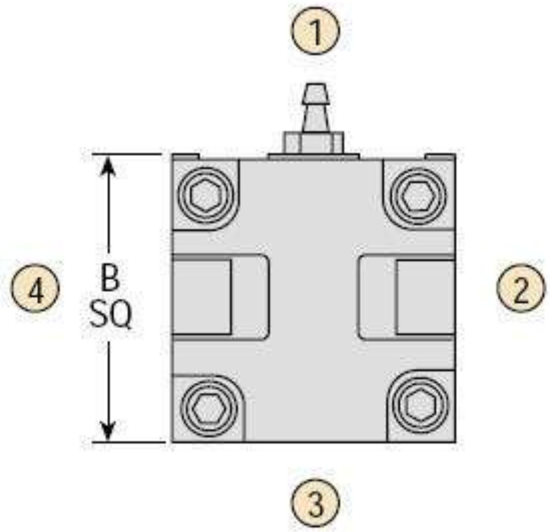
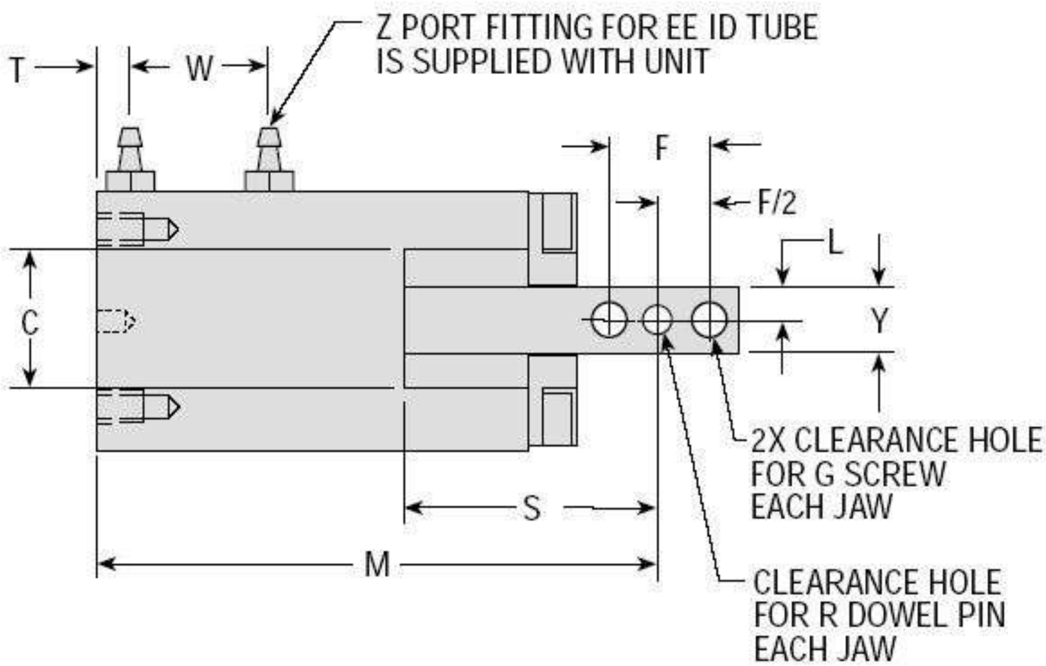
Style 1 jaw is provided with a dowel pin hole as a means of orienting and locating jaw tooling.





Gripper bottom end view is shown above.



Gripper top view is shown above.

Gripper top end view is shown above.

Gripper side view is shown above.

190,191

LETTER DIM.	MODEL NUMBER							
	19160 in	19165 mm	19170 in	19175 mm	19180 in	19185 mm	19190 in	19195 mm
NOMINAL JAW TRAVEL	.157	4	.276	7	.394	10	.512	13
A CLOSED**	.315	7.75	.345	8.75	.581	14.75	.700	17.75
A OPEN**	.403	10.25	.540	13.75	.915	23.25	1.150	29.25
B	.787	20.0	1.024	26.0	1.496	38.0	1.968	50.0
C	.398	10.0	.555	14.0	.791	20.0	1.027	26.0
D	.177	4.5	.215	5.5	.256	6.5	.394	10.0
F	.312	8.0	.375	10.0	.500	12.0	.625	16.0
G	#4	M2.5	#5	M3	#8	M4	#10	M5
H	1.613	41.0	1.970	50.0	2.420	61.5	2.951	75.0
K	2.164	55.0	2.618	66.5	3.285	83.5	4.112	104.5
L	.098	2.5	.138	3.5	.196	5.0	.256	6.5
M	1.913	48.5	2.305	58.5	2.847	72.5	3.525	89.5
P*	.550	14.0	.710	18.0	1.100	28.0	1.535	39.0
Q	4-40 x .19 DP	M3 x 0.5 x 4.5 DP	6-32 x .22 DP	M3 x 0.5 x 4.5 DP	8-32 x .28 DP	M4 x 0.7 x 6.0 DP	10-24 x .38 DP	M5 x 0.8 x 7.5 DP
R	3/32	2.5	1/8	3.0	1/8	4.0	3/16	5.0
S	.871	22.0	1.045	26.0	1.412	36.0	1.854	47.0
T	.167	3.0	.176	3.5	.193	5.5	.153	4.5
W	.465	12.5	.505	14.5	.592	15.0	.750	19.5
Y	.196	5.0	.276	7.0	.393	10.0	.511	13.0
Z	10-32	M3 x 0.5	10-32	M3 x 0.5	10-32	M5 x 0.8	10-32	M5 x 0.8
EE	1/16	2.5	1/16	2.5	1/16	3.0	1/16	3.0

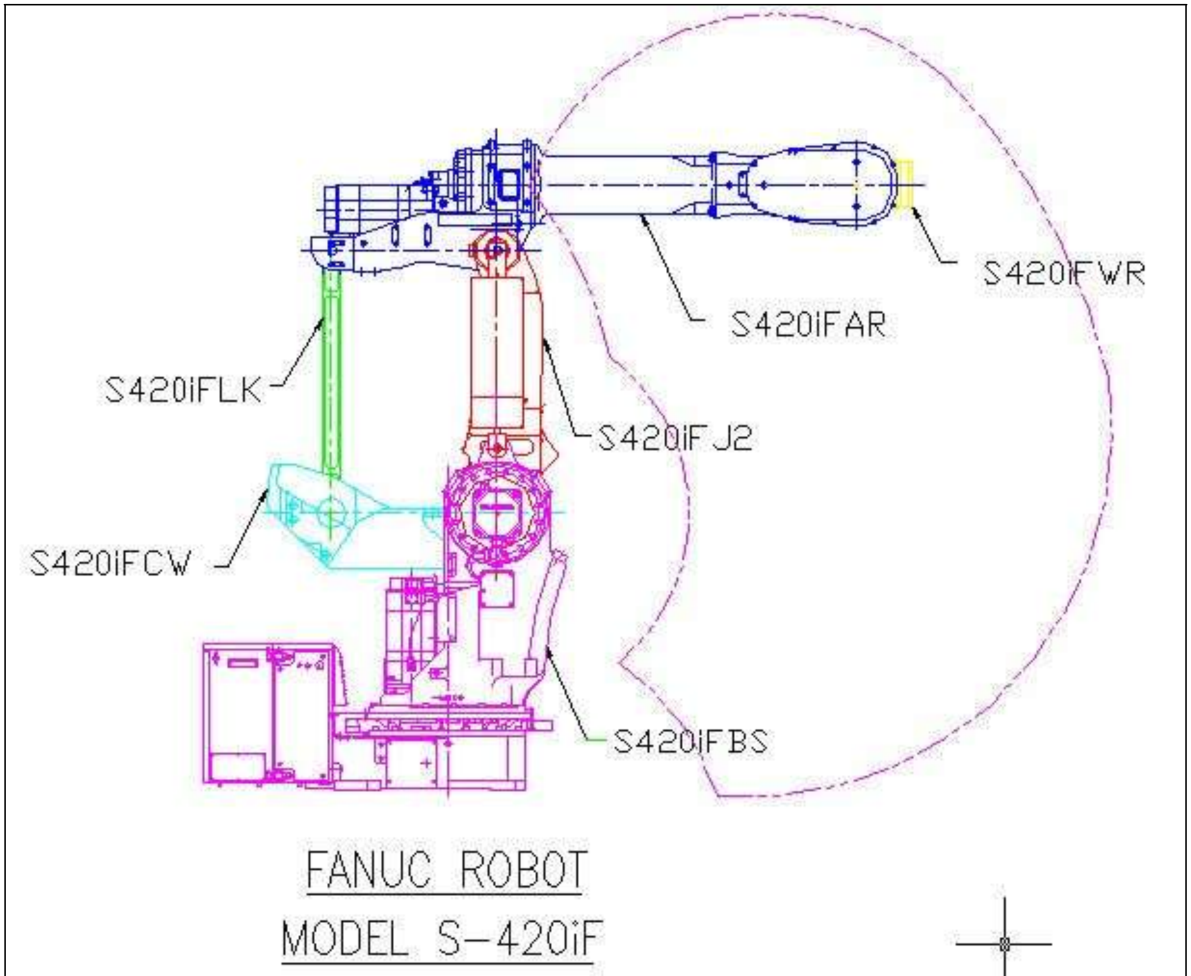
NOTES:
1) *TOLERANCE BETWEEN DOWEL PIN HOLES IS ± .0008 [± 0.02]
2) NUMBERS IN [ ] ARE FOR METRIC UNITS AND ARE IN mm
3) CIRCLED NUMBERS INDICATE POSITIONS.
4) **A CLOSED REFLECTS THE LARGEST POSSIBLE CLOSED DIMENSION.
A OPEN REFLECTS THE SMALLEST POSSIBLE OPEN DIMENSION.

This is the end of the Gripper Tooling Design Project

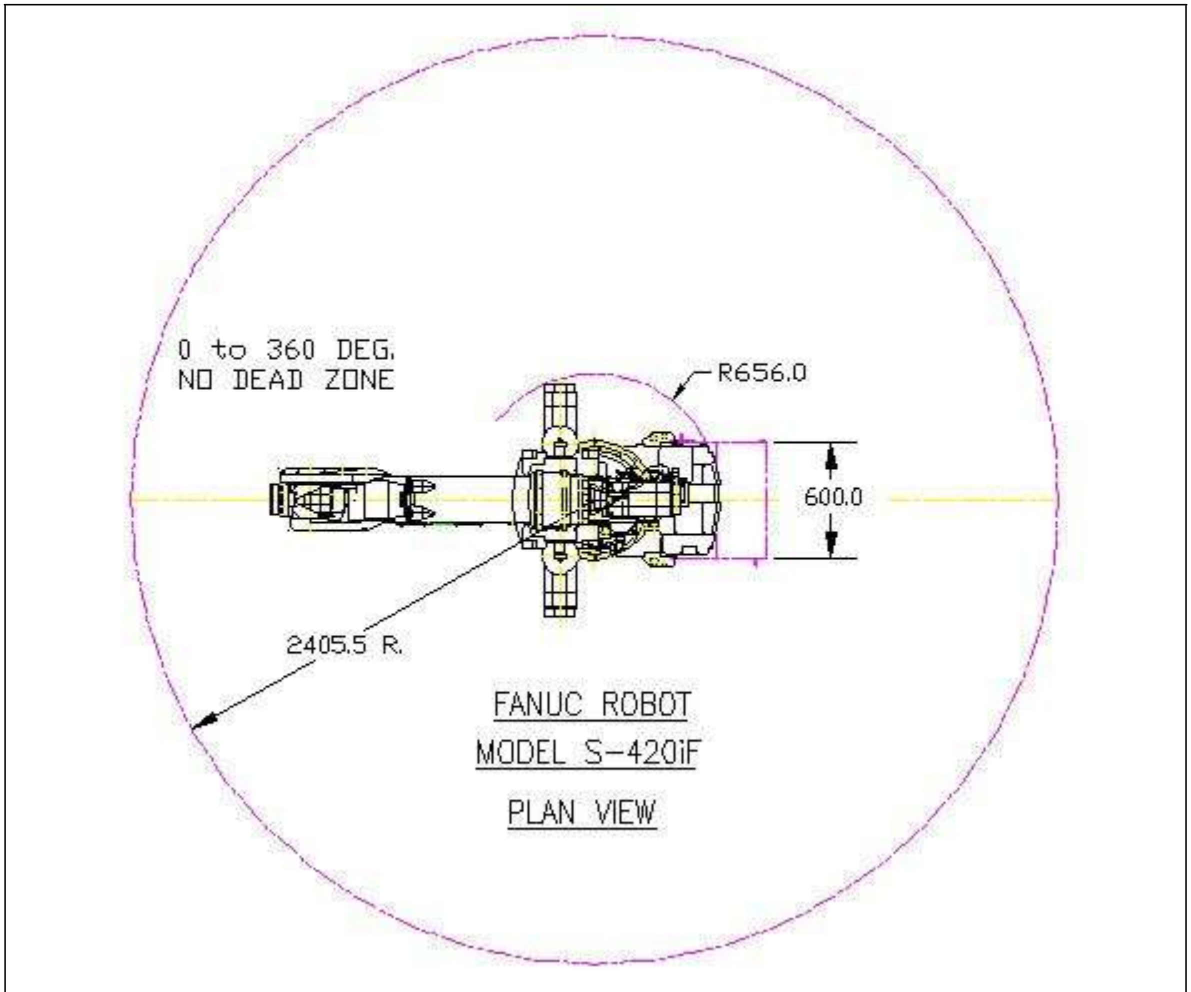
The notes below refer to Fanuc Industrial Robots

Information about Fanuc Industrial Robots can be found at:

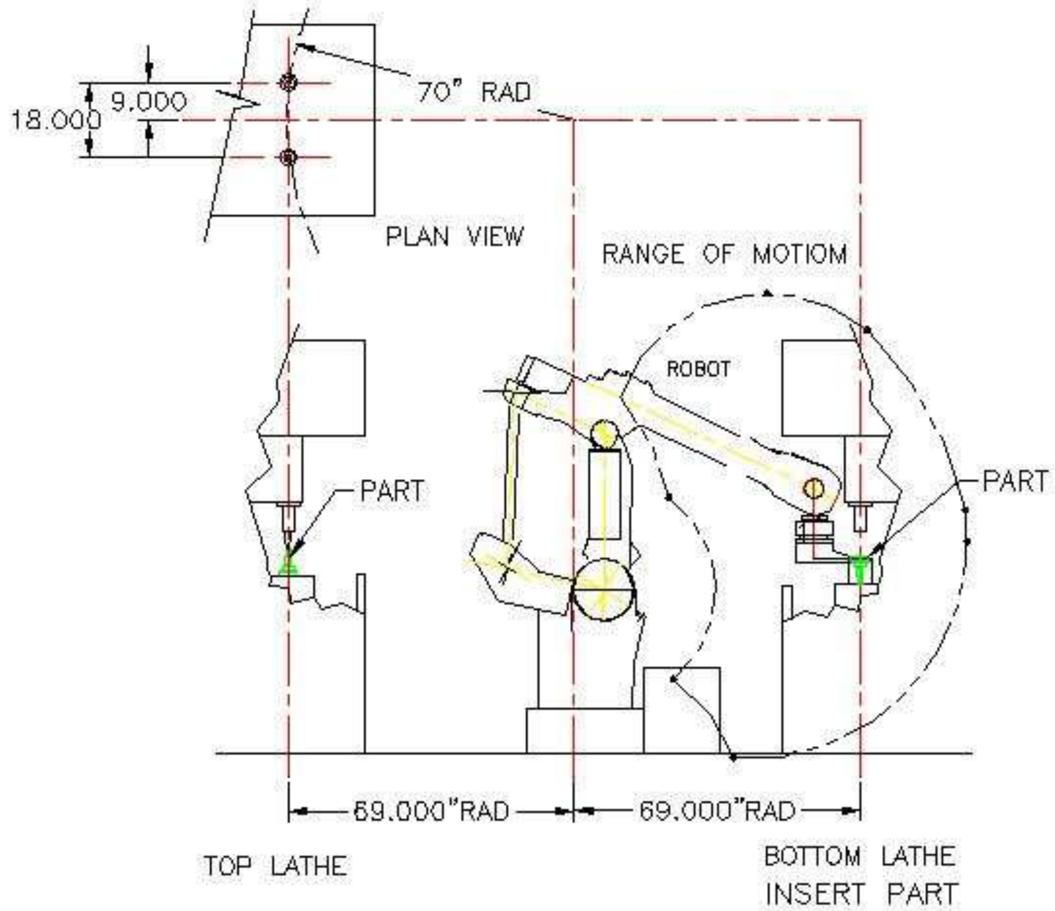
http://www.fanuc.co.jp/en/product/robot/index.html



A side view of a Fanuc industrial robot is shown above.



The maximum reach radius of the Fanuc Model S-420iF robot arm is 2405.5 millimeters or 94.705 inches.



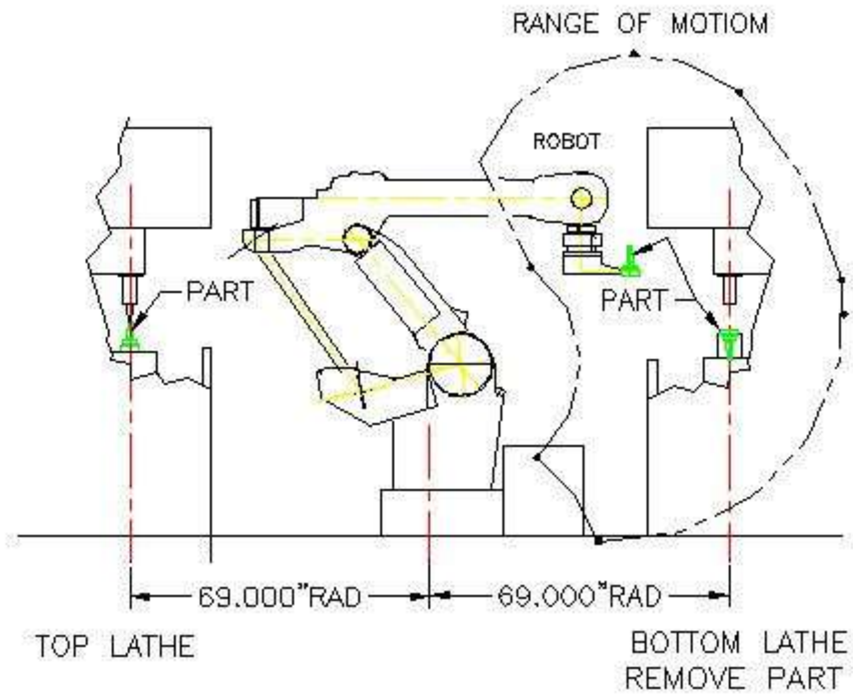
A robot is placing two parts in a double spindle vertical lathe on the right side.

The bottom portion of the two parts are machined at the same time.

To the left of the robot is seen a second double spindle lathe.

After machining the bottoms, the pair of parts are removed from the “Bottom Lathe”, rotated 180 degrees by the robot gripper, and placed in the “Top Lathe”.

When the bottoms and tops of the two parts have been machined, the robot removes them from the Lathe and places them in the discharge conveyor.



The two parts are removed from the Bottom Lathe and rotated 180 degrees and the pair of parts are inserted into the Top Lathe as shown above.

Next the parts are placed in the Top Lathe.

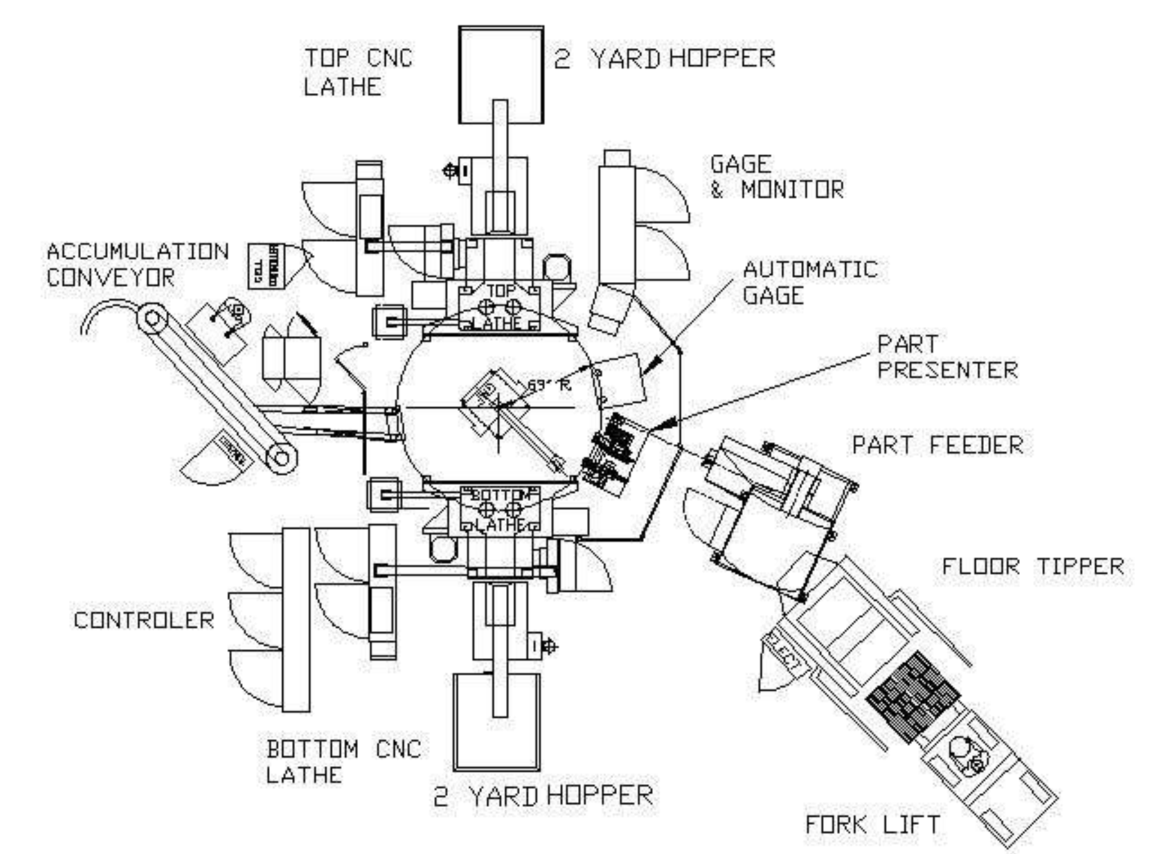
On the right, a pair of parts are placed or inserted by the robot, with its specially designed gripper, into the lathe chuck.

The robot must move fast enough to keep up with the two Lathes.

Machining should never have to wait for material handling.

The left side of the drawing shows the parts removed from the Lathe after the bottom portion of the parts have been machined.

When the machined parts are removed, a pair of "green", or un-machined parts, are inserted into the empty chucks.



Robot Operating Sequence

Turn the Robot to the teach mode:

1. Pick parts, 2 at a time from the parts presenter. The 2 parts are gripped by the upper left pair of clamps.

2. Remove the finished parts in the lathe that turns the tops with the bottom right pair of clamps. Insert the 2 green parts into the lathe that turns the tops.

3. Rotate the pair of machined parts so that the tops are up in front of the chip stripper. Stroke the tops of the 2 parts against the chip stripper wires.

4. Remove the 2 parts in the automatic gage with the 2 left clamps.

5. Place the 2 parts in the right clamps into the automatic gage. Lower the parts into the 1/8" high collars at the bottom end of each part.

6. Rotate the pair of machined parts in the left clamps so that top is down in front of the lathe that turns the bottoms. Remove the 2 machined parts in the bottom lathe with the 2 right clamps. Insert the 2 top down parts in the left clamps so that the tops are no more than 3" above the lathe chucks. Insert the 2 parts into the lathe that turns the bottom.

7. Drop the 2 machined parts in the right clamps top down onto the output conveyor.

CNC Lathes

A plan view of the Top and Bottom Lathes are shown above in a fully equipped machine cell. The tops of all parts are machined in the Top Lathe. Then the bottoms are machined in the Bottom Lathe.

Since both Top and Bottom Lathes are machining at the same time and almost continuously, the total machine time can be minimized if both Lathes take the same time to machine a pair of parts.

Part Feeder

A Fork Lift Truck places "Green", un-machined parts in a Gondola or metal box into a Floor Tipper. The Floor Tipper raises the Gondola and tips the parts to be machined into a Part Feeder. The Part Feeder separates, raises, and arranges parts in single file on a gravity chute conveyor that transports the parts to the Parts Presenter.

Part Presenter

The Part Presenter has a smooth flat top chain conveyor that runs continuously. Two air cylinders each fitted with a blade that projects across the conveyor, meter the parts one at a time to the left stop or the right stop. When both left and right stops have parts present, and the previous parts have been removed, each part is pushed forward by an air cylinder.

Automatic Feedback Gage

Five critical dimensions of each of the parts are checked by the Automatic Gage. If any of the dimensions are out of the tolerance zone the Automatic Gage sends feedback instructions to the Lathe.

The Lathe tools move in response to correct the potential error. If dimensions are found to change from the specified range, the lathe automatically adjusts cutter positions to improve accuracy.

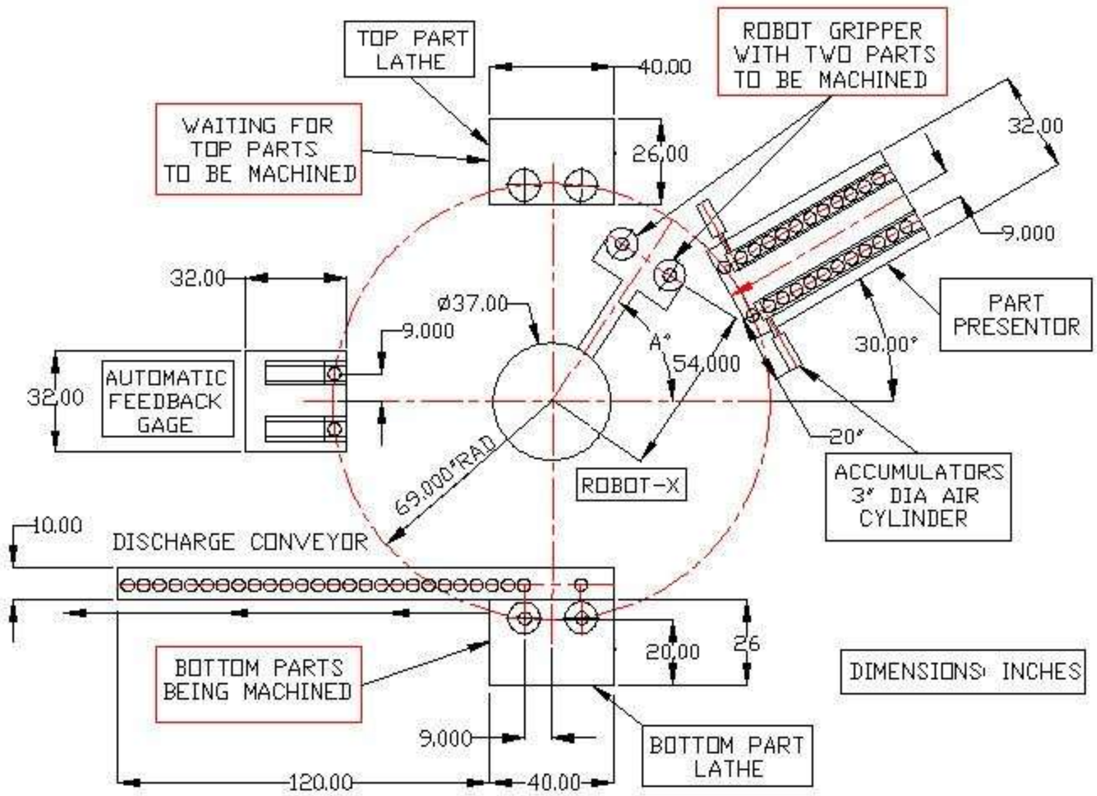
Each dimension is sensed with a tiny air jet. The pressure in the air jet varies according to the distance between the jet outlet and the surface being gauged.

Output Conveyor

The two gauged parts are next moved by the Robot to the other lathe where the bottom sections are machined. These two parts that now have machined tops and bottoms are inserted onto the Output Conveyor which transports the finished pair of parts to the storage conveyor.

Robot Gripper or End Effector

The Gripper at the end of the Robot arm has 4 clamps which hold 4 parts, 2 parts to be machined and 2 parts which have been machined. Special brackets must be designed for each new product to be held by Robot Grippers.



ROBOT PICK AND PLACE CELL PROJECT

1. Make a CAD drawing of the pick and place robot machine cell specified above.

2. Move the two lathes, part presenter, and feed-back gage around the 69.000" radius circle to reduce the time to machine the top and bottom of the two parts.

3. Rotational speed of the robot arm is 360 degrees in 6.00 seconds.

4. Travel angle from part presenter to top lathe is 90 - 30 = 60 degrees.

5. Angular travel time from part presenter to top lathe is:
60 deg./ 360 deg. x 6.00 sec. = 1.00 seconds.

6. Placing a work-piece takes 2.00 seconds and includes:
a. Extend 9.000"

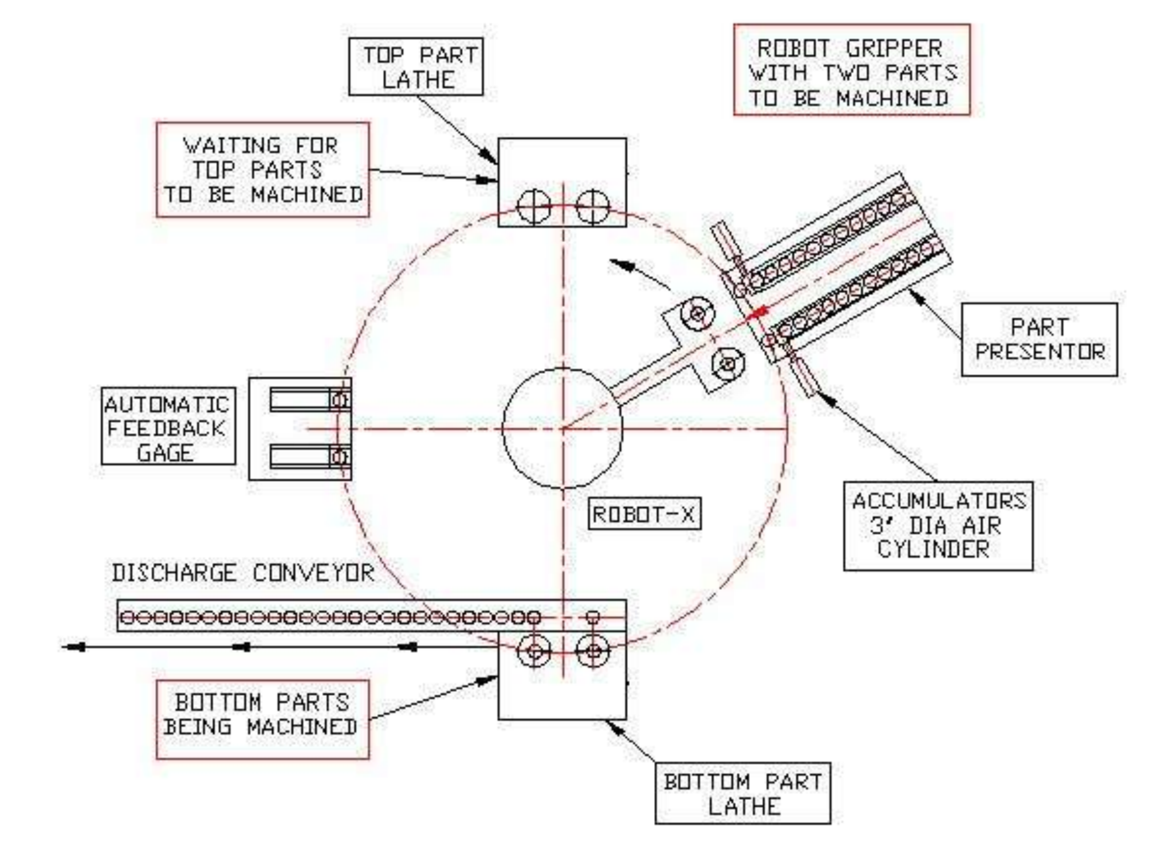
b. Gripper closes on work-piece.
c. Robot arm lifts work-piece out of lathe chuck.
d. Retract 9.000"

7. Removing a work-piece takes 2.50 seconds and includes:
a. Extend 9.000"
b. Robot arm lowers work-piece into lathe chuck.
c. Gripper releases work-piece.
d. Retract 9.000"

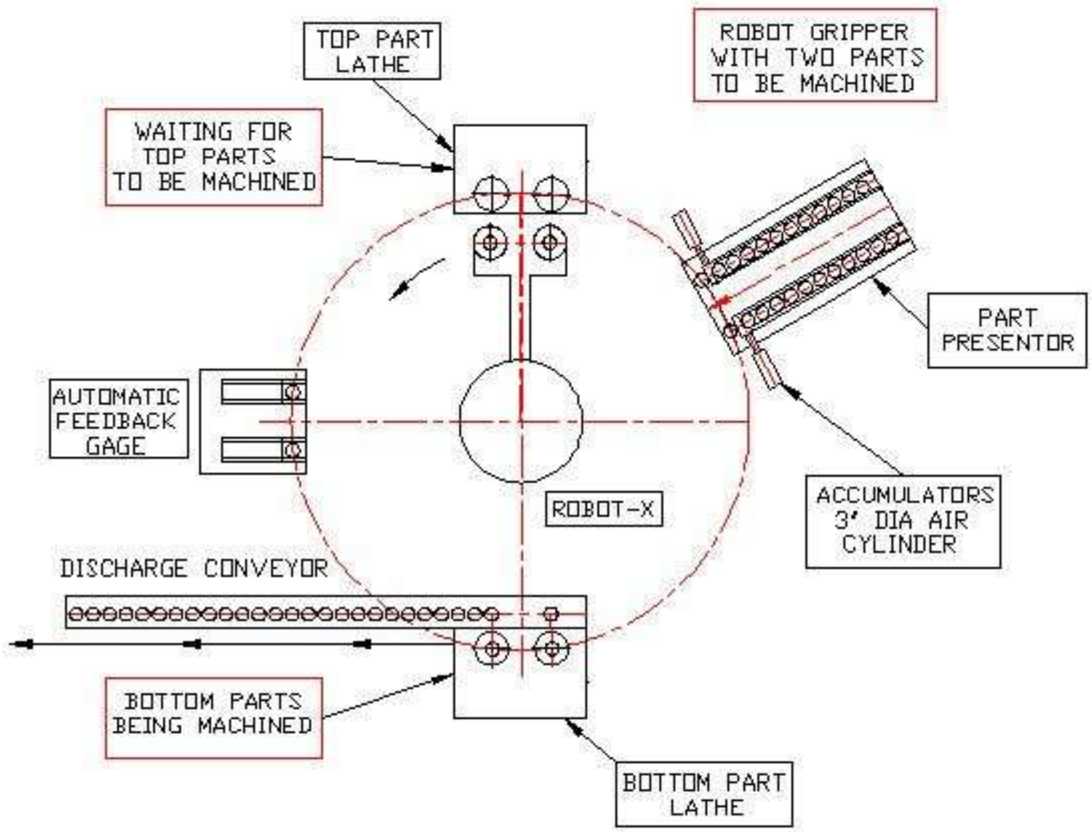
8. Total travel time for the existing pick and place machine cell is 21.00 seconds as calculated in the table below.

Robot Movements	Rotation Angle Degrees	Rotation Time seconds	Place seconds	Remove seconds	Total Time Seconds
1. Part Presenter to Top Lathe	60.00	1.00	2.00	2.50	4.50
2. Top Lathe Machining Completed				4.00	4.00
3. Top Lathe to Automatic Feedback Gage	90.00	1.5	2.00	2.50	4.50
4. Bottom Lathe Machining Completed				5.50	5.50
5. Bottom Lathe to Discharge Conveyor				2.50	2.50
				Total Time to Machine 2 Parts:	21.00

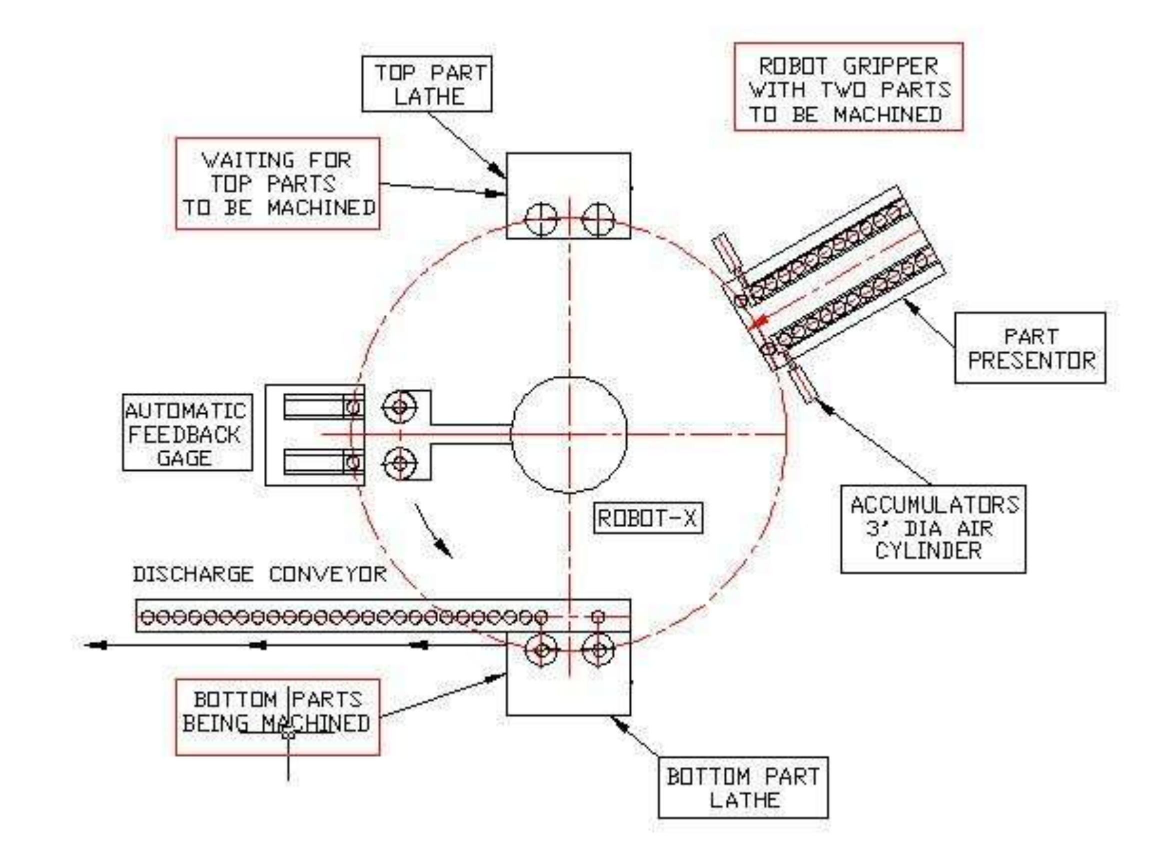
The above sequence of operations are illustrated in the four diagrams below.



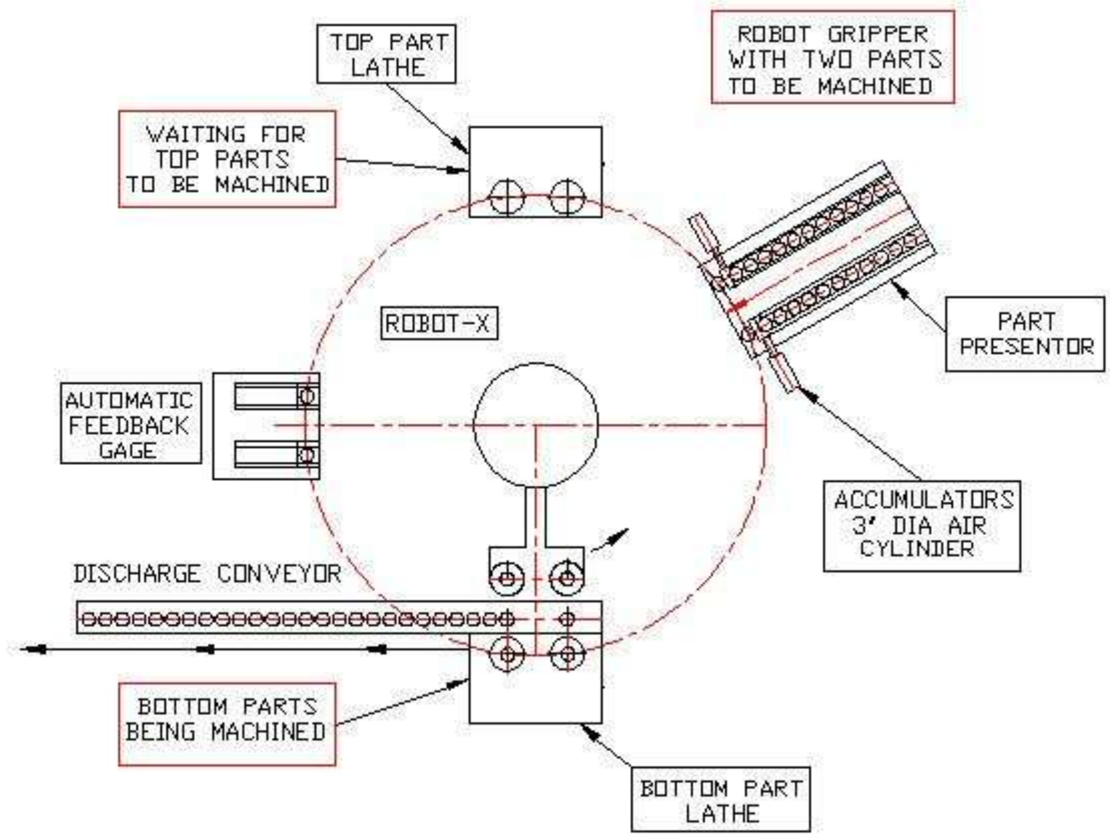
1. Part presenter to top lathe is shown above.



2. Top lathe machining is completed above.



3. Top lathe to automatic feedback gage I seen above.



4. Bottom lathe machining is completed above and

5. transfer from bottom lathe to discharge conveyor and

6. bottom lathe to part presenter begins a new cycle.

Robot Machine Cell Economics

Manual Machine Cell

The existing manual machine cell cycle time to produce one pair of parts is 26.00 seconds.

Each workday is three 7.5 hour shifts or 81,000 seconds.

Existing daily production is 81,000 / 26.00 = 3,115 pairs of parts.

Robot Machine Cell

The robot machine cell cycle time will be 21.00 seconds per pair of parts.

The new daily production will be 81,000 / 21.00 = 3,857 pairs of parts.

Production Volume Increase = 3,857 – 3,115 = 742 pairs of parts.

The cost to produce one pair of parts is $23.00.

Sell price for one pair of parts is $46.00

Gross profit per pair of parts sold is $46.00 - $28.00 = $18.00

Robot machine cell daily revenue increase = $18.00 x 742 = $13,356.

Cost of adding a robot to the convert the existing manual machine cell is $1,500,000.

Payback Period

The time span for the investment in capital equipment is:

The payback period is $1,500,000 / $13,356 = 112 days.

Management will decide if 112 days is an acceptable payback period.

Related Links

Advanced Automation provides, designs, manufactures, and integrates custom automation systems at: http://www.aautomation.com/

DeStaco Automation equipment can be found at: http://www.destaco.com/index.asp?site=7

Robohand pick and place equipment is at: www.fusebox.com/Robohand/

Information about pick and place grippers can be obtained from: www.phdinc.com.

Fanuc Industrial Robots can be found at: http://www.fanuc.co.jp/en/product/robot/index.html

See www.automationdirect.com for information about event driven control systems.

For information about the Human-Machine-Interface shown above see www.rousselet-robatel.com

Information about laser sensors and vision systems can be found at: http://world.keyence.com

Find information about automatic screwdrivers and feeders at:

www.assemblyandautomation.com

More vibrating bowel part feeders at: www.designtoolinc.com

Prices and descriptions of over 420,000 industrial: materials, parts, and equipment are at: www.mcmaster.com

The United States Patent and Trademark Office Home Page at www.uspto.gov Provides links to information about all aspects pertaining to invention patents.

This is the end of the “Pick and Place Robots” lesson.

Please go to the Quiz.