Robotised Machine Tending

With MOTOMAN Robots
Built to perform

YASKAWA
Robotised machine tending increases productivity. Whether tending one or several machines, the robot works continuously and unmanned operation is possible.
Productivity
A robot operated machine or group of machines will be more productive than manual operation because the robot works continuously with constant cycle times and makes unmanned operation possible.

With robotised operation a virtual simulation of the cell work flow can be easily undertaken. This allows cycle times to be accurately estimated or verified and production costs defined. Signals, opening/closing of safety devices, work piece deliveries, cleaning operation etc. are included in cycle time calculations to ensure accuracy.

Robotised operation also means that heavy, monotonous and perhaps risky tasks are removed from the staff’s duties and they become robot operators instead. This is often a positive change that increases motivation.

Flexibility
Robotised operation offers flexibility. It is possible to combine robotised operation with manual operation. For example, it is possible for a cell to contain several machines, some of which are manually operated while the robot is operating the others. Safety zones and buffer storage ensure safety and increased productivity.

Depending on the requirement it is also possible for machines in robotised cells to be operated manually if this is necessary for the production of prototypes or small batches.

Profitability
Robotised operation is ideally suited to the manufacture of recurring products in reasonable batches, but even the production of small batches can be profitable automated by robot if the products resemble each other and the similarities are used to make up a total volume that is large enough.

If the opportunity for unmanned operation is used, the cell will become profitable even faster. To increase the productive time of the cell during unmanned operation the cell can be provided with buffers, a place for infeed pallets, or conveyor systems for transporting goods in and out of the cell.

Robotised operation also increases profitability by increasing quality. As a result of the robot’s exact movements the number of products that need to be discarded is diminished.

Automatic machine tending with an industrial robot is a flexible solution which makes it possible to make changes in the cell according to production requirements.
Industrial robots
The MOTOMAN robot family comprises a large range of six axes servo powered industrial robots. Robots suitable for machine tending are available with a maximum payload, including gripper, from 3 to 500 kg.

In order to increase the robot’s reach it is possible to integrate a seventh axis in the control system either as a rotating robot turntable or a traverse track. The turntable increases the maximum reach by up to 1100 mm while the traverse track can transport the robot twenty meters or more.

Gantry robot
YASKAWA’s product range also includes two and three axis gantry robots with a maximum payload of up to 500 kg/robot arm. The gantry robot tends the machine from above which means that even during robot operation the operator has access to the machine’s front.

The gantry robot is equipped with one or several arms, which it moves along a beam. The arms can have normal or rotation grippers, in which case the gantry robot will also be able to perform pendular or rotating movements.

The linear gantry robot can move its arms up to 30-40 meters and the horizontal gantry robot, which has one more axis for movement, can use its arms over a whole surface area.

Tending machine
YASKAWA has experience of installations with milling Machines, athes, grinding machines and special machines of all the leading brands*, for example: Brother, Danobat, Gildemeiser, Haas, Heller, Hüller Hille, Ixion, Kellenberger, Liebherr, Liddö ping, Matsuura, Mauser, Mazak, Mollart, Monfort, MoriSeiki, Nagel, Nakamura, Okuma, Pittler, SAJO, Soarer, SMT, Stama, UVA.

*) The machine’s interface must be approved by YASKAWA.

A servo powered robot turntable, integrated in the control system, is often used to increase the robot’s reach.

A traverse track can be assembled to a suitable length from any number of 3-meter modules.

The horizontal gantry robot with one arm for machine tending which can work over a small surface.
A simple cell for mixed production

This cell is designed for mixed production, where the machine can be tended either by robot or human operator.

The design takes into consideration the operator’s need for space in front of the machine when operating or changing tools. The operator is also able to keep his raw material close to the machine. The robot has been mounted in such a way that it does not take up unnecessary space while being parked in its idle position.

The cell’s safety zones are designed so that material can be transported in and out of the cell without the need to open doors and interrupt production.

Increasing the automation

The robot cell can be made more automatic by adding equipment for palletising, de-burring, measurement etc.

Work shop example

Robot cell for a single machine. Manually changeable robot grippers, a platen conveyor with 20 plates. The robot is mounted on a tilting robot stand which increases the operator’s access to the front of the machine.

1. MOTOMAN industrial robot (idle position)
2. Robot controller
3. Lathe
4. Platen conveyor
5. Pallet
6. Photo cell (alerts operator)
7. Light guard (breaks the safety circuit)
8. Interlocked sliding door
9. Safety fence

The platen conveyor is well suited for irregular objects which will be positioned exactly on the conveyor. If needed fixtures can be added to the plates. The conveyor design is compact and reliable and constructed for a maximum payload of up to 20 kg per plate.
Large volumes in serial flow
Production of large volumes of similar products in a serial flow is well suited to automation with industrial robots.

It is also possible for such a cell to incorporate access to the machines for the operator. More than one safety zone makes it possible to operate one machine manually while the robot is busy in the other parts of the cell.

Using light guards instead of sliding doors makes the transport of material with a forklift in and out of the cell much easier.

Palletising with layer sheets
Letting the robot palletise the products on a pallet with separating layer sheets saves manual labour before delivery. The layer sheet can be specially designed for a particular product or can be standard material such as masonite.

Manual measurement
The robot delivers work pieces to a manual measuring station in the safety fence. The measuring interval is programmed into the robot job beforehand.

There will be one less manual task before delivery if the robot is able to palletise the products with separating layer sheets. The robot changes to a vacuum gripper in order to handle the sheets.
A robot cell with several machines for volume production of similar products. The robot picks up details from a conveyor belt, tend a milling machine in two steps, de-burrs and finally palletises with layer sheets.

1. MOTOMAN industrial robot
2. Robot controller
3. Lathe
4. Draw broach
5. CNC machine
6. Manual inspection station
7. De-burring station
8. Parts feeder
9. Pallet and layer sheets
10. Conveyor belt
11. Photo cell (alerts operator)
12. Light guard (breaks safety circuit)
13. Safety fence
More than one cell with one robot

With a gantry robot it is possible to simultaneously operate two neighbouring cells. The gantry robot has one or more arms that can be moved on a long beam.

Each cell contains its own tending machine, equipment for measurement, labelling, in and outfeed conveyors etc. and between themselves they can manufacture different products. On the other hand it is possible for them to share other equipment, like a washing machine, marking stamp or similar machine.

Access during robot operation

Both cells can also be tended manually. It is possible for the operator to be standing in front of the machine even when the robot is in operation. This is due to the fact that the gantry robot’s arm is performing its tasks from above, through the machine’s roof.

Controlled by a cell computer

When there are several production units working in unison, or if there is a need for supervision and documentation, a cell computer can be used.

The cell computer gathers the information it needs to run the plant with regard to order intake, storage buffers, alarms and documentation. It provides a complete picture of all production units and can transfer the correct machine tending program to each machine. With a cell computer it is easy to run the whole plant from one single location.

Technical data for YASKAWA gantry robots

<table>
<thead>
<tr>
<th>Gantry robot</th>
<th>Payload</th>
<th>Vertical stroke</th>
<th>Positioning speed</th>
<th>Repeatability</th>
<th>Sound level</th>
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<tbody>
<tr>
<td>M12-Y</td>
<td>30 kg</td>
<td>1200 mm</td>
<td>X=100 m/min</td>
<td>± 0.1</td>
<td>&lt;75dB(A)</td>
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<tr>
<td></td>
<td></td>
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<td>Y=70 m/min</td>
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<td></td>
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<td></td>
<td>Z=70 m/min</td>
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<tr>
<td>M15</td>
<td>50 kg</td>
<td>1500 mm</td>
<td>X=100 m/min</td>
<td>± 0.1</td>
<td>&lt;75dB(A)</td>
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<tr>
<td></td>
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<td>Y=70 m/min</td>
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<td></td>
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<td></td>
<td>Z=70 m/min</td>
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<tr>
<td>M15</td>
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<td>1000 mm</td>
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<td></td>
<td>Z=35 m/min</td>
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<td></td>
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</tbody>
</table>
The linear gantry robot is serving two cells, each of them equipped with a lathe, an automatic measuring machine, infeed and outfeed conveyors. The gantry robot's arms are working vertically and they are tending the machine from above, which gives the operator access to the machine front even during robot operation. A single computer controls the whole plant.

1. MOTOMAN gantry robot
2. Cell computer
3. Lathe
4. Platen conveyor
5. Measuring machine
6. Washing machine
Large volumes in parallel flow
A robot cell for several machines can be constructed for a parallel work flow, i.e. different products are manufactured in the cell at the same time.

The safety around the cell is designed so that one or several machines can be tended or adjusted manually while the robot operates the other machines. Each machine has its own security zone protected by a laser scanner.

The transport of materials in and out of the cell is performed so that robot operation is not interrupted.

Wide range of similar products
When the products resemble each other, it is possible to use the similarities to simplify the robot jobs with parameter programming.

In this case the grippers are designed to handle as many of the products as possible, or all of them, in order to minimize the need for a gripper change or tool adjustment between different batches.

It also makes things easier if the work pieces can be picked up by the robot from a datum magazine which has been designed to fit the whole product range.

Useful features in the control system

Parameter programming means that only some dimensions from the work piece and the finished product must be fed into the control system which then adjusts the robot job to suit the actual product.

The Search function is useful if there are variations in the dimension of the work pieces or their position on the pallet. Data from a sensor automatically adjusts the robot job.

The function Servo Float lower the power to the servo motors and makes the robot arm responsive to external forces, e.g. when placing a work piece against a tool.

Conveyor synchronisation means that the robot’s motions follows the speed and position of the conveyor. This function can be used pick up as well as placing work pieces onto the conveyor without stopping it.

The integrated Collision control prevents robot, tools, fixtures etc. from being damaged during a possible collision. The momentary limits can be individually set depending on the application.

The control system can communicate with a PC using a PC-card (PCMCIA), serial RS-232C or Ethernet connection. For complex I/O installations there is a fieldbus board available which supports the most common standards (Interbus-S, Device-Net, Profi bus etc.).
A robot cell with several machines for volume production of similar products in a parallel work flow. One or several machines can be tended manually. The whole cell uses parameter programming where a few dimensions are fed to a cell computer which then adjusts the robot jobs.

1. MOTOMAN industrial robot
2. Robot controller
3. Lathe
4. Cell computer
5. Vision camera
6. Datum magazine
7. Outfeed conveyor
8. Laser scanner
9. Safety fence
**Volume production in small batches**

“Just-in-time” production often means many small batches of similar products that together make up a larger volume. The work flow through the cell is always serial, but the operations involved may differ from one product to another.

In this case more than one gripper may be needed, not just for the products but also for the palletising with layer sheets. Here it is often profitable to use an automatic gripper changer where the robot changes its tools by itself.

A vision system may also be incorporated into the cell if incoming parts are hard to position exactly. In this case the robot will be guided by a camera. The whole plant is controlled from a cell computer which also automatically changes programs in machines and robots.

**Testing and identification**

Products can be automatically measured and marked in the cell in order to maintain quality and ensure identification.

*By mounting a temporary flange on the products it is possible to have them all turned in the same lathe without changing tools. A smaller robot is assembling the flange with a screw driving end effector.*
A robot cell for large volumes of similar products in small series. The cell includes: vision system to guide the robot during pickup, automatic marking and measuring equipment, automatic gripper exchanger. The cell is controlled by a cell computer.

1. MOTOMAN industrial robot
2. MOTOMAN gantry robot
3. Robot controller
4. Cell computer
5. Infeed conveyor with vision camera (ceiling)
6. Pallet magazine
7. Automatic gripper changer
8. CNC machine
9. Screw driver (robot station)
10. Lathe
11. Measuring machine
12. Marking stamp
13. Layer sheets
14. Safety fence
Material transport
There are many ways of transporting material in or out of the robot cell. Some of the alternatives are: platen conveyor, pallet (datum magazine), flat belt conveyor, gravity or powered roller conveyors, rotating tables, carts etc.

The best solution for a particular cell depends on the product itself, the cell’s cycle times, batch size and the type of production before and after the robot cell.

Gripper tools
The robot’s grippers are constructed from standard components which makes them easy to assemble and modify at a reasonable cost. A gripper can also be designed to handle more than one type of product or for making manual changes easier.

Changing grippers manually can be avoided with an automatic gripper changer where the robot changes its own tools when needed. The robot can also be equipped with a permanently mounted gripper with many functions, providing there is sufficient room for the robot to manoeuvre in the cell and that it has adequate payload capacity.

Turning station
It is not unusual for the work piece to need to be turned once or twice to be machined in several steps. The turning station can either be active or passive. An active station is a gripper with rotating abilities and the passive station is simply a place where the robot makes a re-grip.

Cleaning machine parts
The robot can be equipped with a nozzle and valves so that it can regularly air blast work pieces, fixtures and machine parts.

Keeping the contact surfaces of the machine free from dust and debris is important in order to be able to maintain standards of manufacturing quality.

Making sure that the machine parts are regularly freed from dust, debris and shavings ensures that products can be manufactured with precision and quality.
Vision systems

Some products are difficult to palletise so that they can be picked up by a robot. This can be solved with a system which provides the robot with the visual information it needs to locate the products.

The YASKAWA control system for robots is already prepared for communication with a vision camera. The camera images can guide the robot in the same plane or determine the angle of incoming parts. The robot guiding is based on two-dimensional pictures. To achieve the required contrast between objects and background extra lighting can be installed or the material on which the pieces are presented changed.

Other forms of robot guiding are also available. A mechanical sensor connected to the control system is excellent for height detection and can be used when the robot needs to search down in order to pick up the next piece in a stack.

Deburring

The robots programmable free movements enable it to follow the work piece’s outline for example during brushing, polishing or de burring. It can either hold the workpiece towards a fixed/flexible deburring tool or vice versa, i.e. handling the de-burring tool to a fixed work piece.

Measuring equipment

Products can be measured either with automatic measuring equipment within the robot cell or manually, from a manual inspection station where the robot delivers work pieces to the operator. The interval for measuring can be programmed into the robot job.

Tracking and tracing

For production that requires the need to track and trace products there are many kinds of marking equipment that can be integrated in the robot cell. Some examples are mechanical marking stamps or ink jet printers which can print on labels or the product itself.

Two-dimensional pictures from the vision camera can help the robot orient itself to unevenly positioned parts.

Products can easily be measured on a regular basis in the automatic measuring machine within the robot cell.