

Robots in Manufacturing – How the Smaller Machine Provides Automation and Competitiveness

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Introduction

The term “robot” readily evokes a mental image to most people, whether it be the metal friends of the Star Wars movies or a AIBO¹ dog. Industrially, large multi-axis assembly robots are also fairly familiar. We see them regularly on television welding automobiles, or spray painting cars (sometimes, rather artistically and with a mind of their own!).

Figures released by the British Automation and Robot Association (BARA²) for UK robot sales in 2003 show that for the first time in three years there is an upward trend in the numbers of these kinds of robots sold in the UK. With just over 800 units sold last year (up from 750 in the previous year) this is still one third down on the record year of 2000 when over 1200 robot units were sold into manufacturing. Major applications are spot welding and materials handling, and automotive is the sector with the highest usage.

What may not be quite so familiar is the success of the smaller benchtop or desktop robot in industry. Since the mid-1990's, when the sales began to take off, tens of thousands of these smaller machines have taken on assembly tasks and brought automation to even quite small manufacturing facilities all over the world. If benchtop robots are taken into account in the above statistics, total robot usage might possibly be twice that reported.

Benchtop robots – a brief description

With a footprint not much larger than a piece of A4 paper and a working area of 200 x 200mm, the smallest machines still have all the functionality of their larger brethren. Bigger versions cover 800 x 600mm with a Z-axis of 200mm. They are often self-contained, controlled by internal computers.

Typically, programming is by means of a teach pendant, using simple step-by-step instructions. Program inputs are prompted. Programs are stored on the machine or, optionally, can be kept off the machine on a PC. Software can be generic, allowing full control of all functionality by the programmer, or function specific (e.g. dispensing), where the software is customised and even more user-friendly. Point-to-point and continuous path motion are selectable. Whilst 2-axis machines are available, 3-axis are the most popular, with full interpolation of lines, arcs and circles through all three axes. A fourth, rotational axis is used for more complex, non-planar jobs. Positional accuracy is within fractions of millimetres (0.01mm is typical), and movement speeds can reach one meter per second. There are inputs and outputs which allow an interface with external devices (e.g. pick and place pneumatics). They may be driven by servo or stepper motors, with belt or ball screw drives.

With a decade of installed units to reference, this category of machines have shown remarkable reliability. Maintenance is relatively simple, and they are built robustly and fit for shop floor use. They may incorporate self diagnostic procedures in case of malfunctions.



Figure 1 – FIP gasket application on a small, semi-automatic robot

Types

There are three major types of small robot:

- 1) Semi-automatic, batch type cartesian robot – the work is placed on a moving plate on the bed of the machine, which provides x-axis movement. Overhead, a beam provides y-axis movement for the traveller which gives the z-axis movement. (Figures 1 & 2)
- 2) SCARA robot – invented in Japan in the 1960's, SCARA stands for Selectively Compliant Articulated Robot Arm, or sometimes Selective Compliant Assembly Robot Arm. With joints much like a human arm (shoulder, elbow and wrist axes), it performs pick & place or palletising functions, and has useful dispensing opportunities. Benchtop versions are available only 600 x 300mm in size, but with nearly 500mm reach. (Figure 3)
- 3) Gantry robot – the overhead beam moves back and forth over the work, which is on a fixed base. A z-axis component slides on the gantry. (Figure 4)

All types are suitable for semi-automatic batch operation, where the work is manually loaded/unloaded. The SCARA and Gantry types will also work with automatic feed by, for example, being placed next to or over a conveyor.



Figure 2 – Adhesive dispensing on complex, 3-D parts

What do they do?

Robots consist of two parts: (a) a positioning system, which locates (b) the functional part, sometimes called an “end effector”. It is this end effector which defines the robot function, and this is only limited by the engineer’s imagination.

Typical applications for benchtop robots include:

- 1) Dispensing
- 2) Soldering, brazing and welding
- 3) Pick and place
- 4) Screwdriving
- 5) Engraving, cutting
- 6) Testing and calibration

Dispensing

This is one of the most popular applications. Adhesives, sealants, coatings, inks, paints, greases, oils, solder pastes and the like are accurately metered and positioned on the work. The materials are either dispensed from barrels or cartridges mounted on the machine z-axis, or remotely located and fed through a robot mounted valve which controls the flow. Beads, coatings or micro-dots are common. Metering and mixing equipment can be interfaced to the robot to dispense two part systems like adhesives, encapsulants or potting compounds.

One very popular application is the dispensing of form-in-place (FIP) gaskets. A bead of adhesive is dispensed on the part, which is then cured to form a soft, sealing gasket. FIP gaskets offer some advantages over pre-cut gaskets: easier automated application, permanently positioned, much lower inventory and tooling costs and design flexibility. However, it is difficult to dispense a FIP gasket manually. The bead needs to be the same diameter over its entire length, and to achieve this, the dispense needle travel speed must match the FIP gasket

flow rate, even around corners or over a three dimensional surface. A robot can be programmed to do this, whereas a human would find it impossible.

Test & calibration

Benchtop robots have been used in many test and calibration applications. A camera is sequentially positioned by the robot over each of a number of small parts, arranged in an array. At each part, the image is examined by a computer, which can detect a pass or fail state. Reject parts can be identified, marked or even removed whilst on the robot. Alternatively, probes can be accurately positioned to measure electrical or thermal characteristics in a testing procedure.

One application used a benchtop robot to calibrate a thermostat, which was eventually to find its way into a fish tank water heater. The robot was interfaced to electrical testing equipment. The robot positioned a screwdriver onto a calibration screw on the thermostat, and turned the screw until the appropriate electrical output was detected by the testing equipment. The robot can be programmed to perform a task until it receives a signal through one of its I/O ports, and then proceed to the next task.

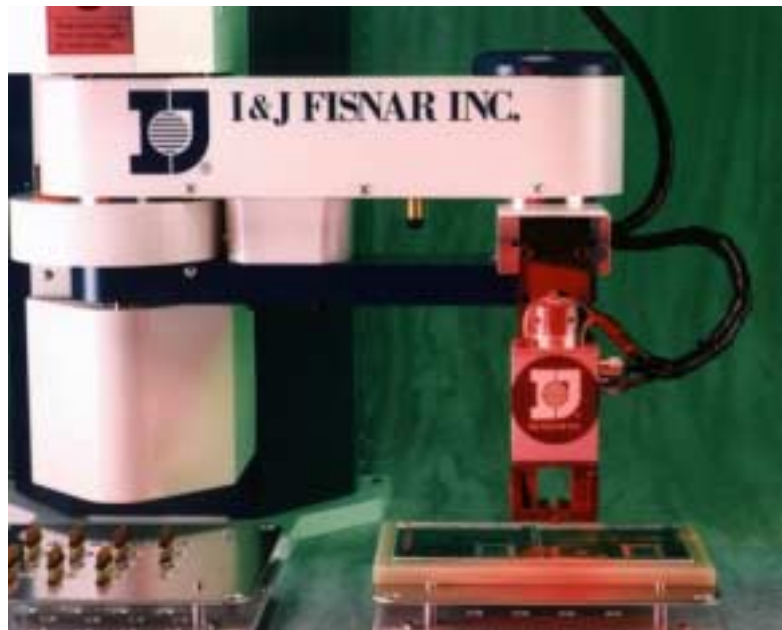


Figure 3 – A small benchtop SCARA robot performs pick & place

Advantages

Whilst there are instances where the decision making capability of a person is needed, robots often take over a repetitive job from a human. They do not mind if the job is boring or unpleasant. Justifications for using a robot include:

- 1) Quality - robots are more consistent and accurate than a human. They do not get distracted nor interrupted. Product integrity is enhanced.
- 2) Production yield - more often than not, reject rates go down when an automated process is installed.
- 3) Throughput – robots do not take tea breaks or holidays. They can be much faster than humans.
- 4) Necessity – sometimes the job just cannot be accomplished by a human (c.f. FIP gaskets).
- 5) Material savings – due to more control and uninterrupted operation, there can be significant economic savings in material usage. Expensive materials like silver loaded conductive epoxies are dispensed accurately and without error or waste. Systems which require mixing (e.g. two part potting compounds) may need purging or changes of mixing nozzles unless dispensed all day without interruption.

Who uses benchtop robots and why?

Like the larger robots seen on television, automotive applications are popular for benchtop robots; they are often found in tier two or tier three manufacturers, making car subassemblies like radios, loudspeakers or fascia parts. They have found many additional uses in all types of technology assembly companies making products like electronic components, optoelectronics, fibre optics and medical devices. A myriad of simple tasks can benefit from the automation, such as the dome coating of small labels and badges.

Besides size, what differentiates the benchtop robot from their bigger compatriots? They are simpler, although they retain a high level of functionality. Software is user-friendly, and there is no need to understand complicated robot or machine language or PLC programming. No previous experience or dedicated automation engineer is

required, so they can be purchased “over the counter”, and regularly represent the first piece of automation for the SME.

Moreover, prices start at about £5,000.00. This brings the technology into the budget range of almost all manufacturing concerns. At this price level, cost justification by reasons of higher throughput and yields, fewer rejects, better quality or reduced labour content are relatively straightforward. Payback times can be as little as six months.



Figure 4 – A table top gantry robot on some larger parts

Future developments

The value proposition will continue to improve, with robot suppliers offering higher performance for the price. Software will continue to evolve, and dedicated functions will improve user-friendliness without sacrificing flexibility. Vision systems will be integrated, offering in-line inspection or the ability to locate parts by means of fiducial or other marks.

The future does hold interesting prospects – already, micro and miniature robots have a mass similar to small animals and insects. Coupled with the use of MEMS and smart materials, we could see smaller robots still.

Conclusion

Benchtop robotics are readily available, simple to implement and surprisingly inexpensive. In consequence, the investment decision has been made much easier as the equation comparing automation costs to labour costs falls more obviously in automation’s favour. This is vital to companies in the UK who would like to see manufacturing stay on these shores rather than disappear to countries with lower labour expenses.

References

- 1) Trademark Sony Corporation
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