FlexLean

Robots challenge low cost labor

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The automotive industry is generally credited with having pioneered the large scale use of robots. Long production runs of identical cars were the ideal field of application for these untiring and reliable workers. Today's market is increasingly putting automobile manufacturers under pressure to offer customers more choice, while at the same time demanding lower production costs. To fulfill these apparently contradictory requests, a single line must be able to produce a mix of different models, and must "learn" to make new models without calling for a total re-design of its equipment – and preferably without even stopping production.

ABB has responded to these demands by making robot cells more adaptable, easier to install and more economic on space. The new generation of cells can produce so cheaply that they can compete with manual labor in low-cost countries – providing manufacturers with an alternative to outsourcing while at the same time raising the quality supplied to local markets.

A contemporary production line for small cars completes a vehicle every 45 seconds all day and every day. The naked body shell of a typical car – the so-called "body in white" (BIW) – is typically assembled from 200 to 400 parts (including the parts used to make sub-assemblies). This means the BIW line (including its sub-assembly lines) consumes this number of parts every 45 seconds. Not only must the robots themselves work like clockwork, but advanced logistics are required to keep the line running.

Another challenge facing such production lines is one of equipment reusability. In the past, a production line was specifically designed for a single car model. When the time came to introduce a new model, a new line had to be designed and built. Such a solution required considerable investment and lead time.

ABB, as a robots supplier and system integrator, has always recognized the value of making such "carry-over" operations as smooth and simple as possible. The first element of this lies in enabling cost savings by allowing as much equipment as possible to be reused. However, although the "carry-over" of individual robots and other components may be relatively simple,

they must still undergo the same configuration and test cycles as new equipment. To provide greater reusability while simplifying the configuration process, ABB introduced FlexiBase. A FlexiBase is a modular robot cell in which the robots, controllers and cabling are pre-mounted on a platform. This is set up and tested in the ABB factory and delivered to the customer as a working module. It requires only minimal configuration before it can start production. This saving is repeated when the cell is reused.

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In this way, the reusability of installations has changed from being a wish to becoming a "leitmotiv". Several recently released car models are produced on older lines. The "carry-over" of such installations is a real challenge for integrators, especially when the new car model is to be assembled on a line that is already running. In such a situation, the production ramp-up of the new model may not stop or slow down production of the other models. Thanks to its experience as a flexible-line supplier, ABB is considered as a reference for "carry-over" operations by different car makers.

So, in addition to a line being carried over from an old to a new model, such flexibility allows a mix of different models to be produced on the same line. The costs of preparing the line for a new model are decreased dramatically as is, by consequence, the risk to the manufacturer if a new model fails to sell as well as forecast.

The "Far East" challenge…

In the growing Asian market, manually operated installations are still the norm, and robots are only used if heavy duty and accurate operation is required. An example of this is ABB's FlexFramer, a car framing station in which two robots manipulate the 500 kg tooling used to enclose the car body to ensure its geometry. Considering the complete line, however, this arrangement does not require many robots. ABB is now proposing a standard cost-competitive solution to compete with the running costs of a manually operated bodyshop: FlexLean.

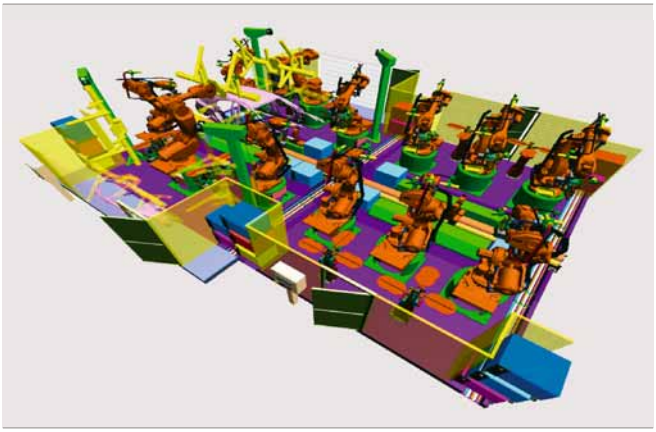
Thanks to FlexLean, it is now possible for the customer to get the flexibility and reliability of a robotized installation at a competitive price compared to the costs of a manually operated one. Moreover, this solution requires up to 40 percent less floor space. The compactness in the modular solution 1 is an advantage from the point of view of quality and logistics (supply of parts). Its scalability is also of advantage when future car models are introduced.

FlexLean

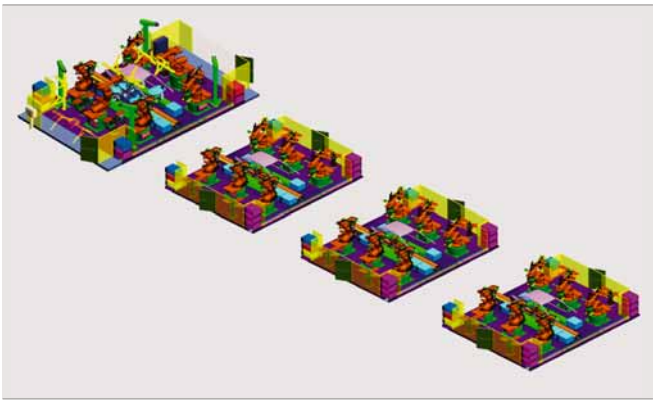
The basic concept of FlexLean is very simple. It builds on the FlexiBase principle, while further raising its adaptability. The "lean" in its name reflects the simplicity, the standardization level, and as a consequence the cost reductions that it enables – making it able to compete with manual labor in low-cost countries, while delivering savings over other robot solutions in higher-cost countries.
At the heart of the concept lies the recognition that customized solutions, multiple technical specifications and dedicated software are a major cause of costs and engineering uncertainty. The answer lies in robot technology and standardization: Two types of such cells are offered 2; one for geo-

3 A robot mounted on a hollow riser. The drive module is contained in the riser, making optimal use of space. Note the absence of cables and pipes from the floor space

1 A high density of robots: Besides saving on floor space, such an arrangement simplifies logistics (supply of parts)



2 An assembly cell and three respot cells. These cells are considered standard products and can be equipped with different process packages



Robotic highlights

Factbox The components of FlexLean – FlexLean incorporates a broad range of new robotic products

IRC5 drive unit

With this robot-control system (which integrates the multimove feature), it is possible to control and coordinate several manipulators, as well as external axes. This is the ideal platform to control the new robotic products such as FlexPLP and FlexGrip.

IRB 6620 robot

A study of the latest OEM projects using ABB robots has shown that value efficiency can be improved by 20 percent. The IRB 6600 is a very good "generic" robot, but offers more capacity than required when it comes to spotwelding applications. The decision was taken to specify, in close collaboration with ABB's robotics division in Sweden, a dedicated spotwelding robot. This new robot would be optimized for its task in terms of cost and performance – the IRB 6620 was born. It has a 2.2 m working range with a 150 kg load capacity – enough to carry a spotwelding gun. The optimization of the arm design is so drastic that the total weight of the robot could be almost cut by half as compared to the IRB 6600! The compactness of this new design makes it possible to increase the density of robots in a cell. Notably, despite the simplified nature of the design (for example, the weight balancing mechanism was omitted) optimization had no impact on motion performance: The new IRB 6620 is as fast and as repeatable as robots of the IRB 6600 family.

FlexPLP: polar

(Flexible Programmable Lean Positioner) This small robot with three positioning axes is used as a positioner to support the car body or workpieces. Previously, jigs would have been used for this. But with different car models being produced on the same line, and each model requiring a different jig, the case for an adjustable solution becomes clear. Typically during work, the car body or workpiece can be supported on four or more FlexPLPs. FlexPLP is available in two versions.

The polar version requires three motors, each of which powers two actuators. The target position is best described in polar coordinates. In the simpler linear version, the three axes are set to the x, y and z coordinates of the target position.

The linear version of such a positioning stage is not new – several models are available on the market – but this one has very specific features. The unit is modular, allowing each axis to be used as a stand-alone product if required. The design is also highly compact and its motor is enclosed for better protection.

FlexPLP: linear

The process cables run inside the three axes of the unit to its extremity, where they power the actuator and collect information from sensors.

The design presented the challenge of protecting the inside of the slide from the harsh environment caused by dust, fumes, welding splatters etc. that characterize the working conditions of a BIW line. The conventional solutions used for protecting such a linear slide influence the stroke, making the unit more cumbersome. Instead, protection had to be achieved by design. The shape of the sliding section allows a cable cover to run through it. This ensures good protection without calling for more conventional bellows, which are both fragile and require more space.

The customer can reap considerable benefits with this technology: Introducing a new car model in the line is just a matter of programming the new positions for locators. This operation can be achieved off-line, using simulation software (such as ABB RobotStudio), with only a short production break for final tuning.

FlexGrip

FlexPLP is a good solution to the challenge of tooling flexibility. Nevertheless, there still remains the problem of using robots to bring various part types into and out of the production line. Usually, such operations call for several end-effectors with tool-changers. In such a situation, the robot leaves its gripping tool in a docking stand and picks another. The drawback of this approach is the floor space required to store grippers, and the resulting effect on cycle times. The FlexGrip module offers a solution that dispenses with the tool changer. Instead, FlexGrip consists of adjustable grippers similar in principle to the linear FlexPLP. The resulting module is specifically designed to be carried by a robot. It is lightweight and the critical masses (motors) are located around the interface with the carrying robot. Several such units driven by the IRC5 controller can be used on the robot end-effector to build a programmable "gripper".

FlexTrack

As customer requirements for bodyshop flexibility increase, another problem arises: how can sub-assemblies, or even a complete car body, be moved across the production line without restricting flexibility? At present, conveyors use model-specific pallets or tooling to handle the parts during motion. These pallets have to be returned to the beginning of the conveyor system when empty. This return circuit is cumbersome, often requiring an aerial system located on a mezzanine. This makes it expensive. Moreover, the co-existence of several car models in production means several pallet types exist, each requiring different treatment. Under such conditions, dealing with more than two car models in the same line becomes a logistical nightmare. Once again, the solution lies in flexible tooling using three-axis robots to position the part locators. This programmable jig is carried by a linear track motion, which like the robots, is driven by the IRC5 controller. FlexTrack was developed for applications where compactness, protection and cost efficiency are required. The compact width allows optimized layouts where the stationary FlexPLPs are close to the linear track. All internal guidance and transmission components are protected against pollution from welding. This linear track motion can also be used to carry robots for various processes such as gluing and palletizing.

An additional strength of such a linear track motion system as compared to a conventional conveyor system is that each car body is moved individually with a very high accuracy and repeatability. This can greatly simplify certain steps. The transfer time is drastically reduced to less than 5 sec for 6 meters.

FlexGrip in action. This variable gripper has four linear positioners which are coordinated to act as a compact robotic "gripper"

A car body supported on FlexPLPs – those on the left are the polar type and those on the right linear

metrical assembly and one for respot[1]. These come with a choice of pre-defined configurations: several process packages (such as spotwelding, gluing, roller hemming) are available for the assembly cell. The number of robots in the respot cell is scalable from two to six.

All equipment belonging to a FlexLean cell, including the controllers, is located on a FlexiBase (steel frame base). This base contains all piping and cabling, resulting in a clean surface that can be walked on without danger of tripping. The compactness is further optimized through newly designed hollow robot risers 3 permitting the IRC5 drivers to be located just under the robot. After startup and commissioning at ABB's facility, each cell is disconnected from power and adjacent cells and delivered by truck to the customer plant, where re-building of the line is achieved in just a matter of hours.

The components of FlexLean are discussed in the Factbox.

Flexibility in set-up

In a production line using FlexLean, each cell is a standalone system. During startup and commissioning, staff can work on isolated cells, as each such cell is controlled by a complete set of automation modules, including a PLC and a man-machine-interface 4. These modules communicate through a three-level bus system:
FieldBus for real-time process,
SafetyBus for critical I/Os and
Ethernet for generic information

The standardization of products used in the cell is not only advantageous for cost reduction, but is also a big advantage for the control system. Complex PLC programming operations are no longer required: every component of the cell is known and the required PLC code is written once for all.

However, one part of the automation still remains variable – the part that is related to the manufacturing process itself. Here lies what is probably the most innovative aspect of this solution: instead of hard coding the spe-

Footnotes

[1] respot is the process providing the final weld after initial welds are used to hold the parts in position.

cific process, FlexControl integrates a configurable sequencer 5a.

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The traditional time-consuming process of programming, compiling, transferring to the PLC and finally debugging the generated code is no longer called for. Now it is just a question of configuring the sequence of operations for each actuator (robots, FlexPLP, clamps 5b etc) by selecting one of the possible operations from a list 5c. The mode switch is then flicked to "auto" and production begins. It is so simple that a PLC programmer is no longer needed to modify the process steps; the person setting up the program merely has to know what he wants FlexLean to do. In production mode, the sequencer is used to display the process status with color codes 5d.

Robots redefine manufacturing

Today, production lines are in existence that can handle a mix of four different models. In future lines, this number may be doubled. There is, however, a limit to the number of models a single line can handle. This comes from the logistics of supplying the parts to the cells: Besides the greater organizational complexity required to handle the increased parts inventory, one fundamental problem is that bringing more part types into a cell demands more space around the cell, and this is already scarce.

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In addition to the different models that are handled, further variants are possible through customization. Each car is defined before production starts, and this information fed to the cell controllers at the appropriate time. This permits, for example, such customization as additional holes or fittings for accessories and avoids expensive subsequent modifications. Manufacturing has come one step closer to the dream of combining mass production with made-to-order individualization.

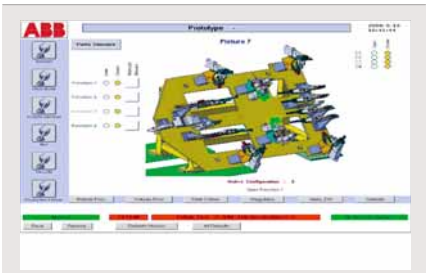
Innovations in robotics serve to make robots easier to setup, use, and re-use, while cutting back constraints such as space requirements and time lost during operations. These advantages are helping position robots in increasingly challenging applications.

4 A robot cell has a multitude of robot controllers. All are centrally configured and coordinated with FlexControl

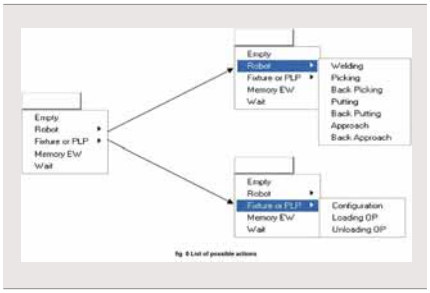
5 The configurable sequencer greatly simplifies the programming of robots

a The sequencer

b Tooling parameters on the sequencer



c A programming example – just a question of selecting the desired action



d In production mode, the sequencer displays the process status with color codes

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