

FlexPicker™ with PickMaster™ revolutionizes picking operations

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IRB 340 Flexpicker™

For many years, ABB has been setting the standard for flexible automation in a wide range of industries. Combining pace with precision, the IRB 340 FlexPicker™, for example, is opening up new markets as it drastically reduces the cost of pick and place operations. A range of refinements, including a brand new software package dubbed PickMaster™, a wash-down version of the IRB 340 robot and an upgraded controller for unparalleled speed and motion control, now give FlexPicker™ even more robotic muscle.

There is a strong need to reduce the cost of pick and place operations in the highly competitive consumer goods industry. Products and their packaging are changing at an increasingly rapid rate in order to appeal to us as consumers, and automation solutions are needed that take full account of this. Human operators are fast as well as versatile when it comes to picking and placing items such as biscuits and chocolates. It is precisely because of this dexterity that such huge demands are made on the agility of automation equipment for this kind of work.

The key to flexible automation of pick and place operations in the

consumer goods industry is FlexPicker™ with PickMaster™, a combination designed with the requirements of this industry in mind. The established benefits of robots include the speed at which they can adapt to new products, their versatility, excellent reliability, availability and endurance.

The new system is based on an extremely fast robot with application software that identifies, picks and places objects on the fly, as human operators do, but more than twice as fast. Chocolates, biscuits and other foods, electronic and engineering components, and pharmaceuticals, are all examples of products for which FlexPicker with PickMaster revolutionizes picking operations.

Short payback time

In autumn 1997 ABB Flexible Automation launched a new palletizing robot – the FlexPalletizer™ IRB 640 – designed to satisfy the repayment targets for investments in the consumer goods industry. This robot with its application software, PalletWare™ and PalletWizard™, is meanwhile reaping success all over the world.

Underscoring its commitment to providing new flexible automation solutions, the company has since introduced the FlexPicker IRB 340, an extremely rapid picking robot – also available in a wash-down version – with conveyor-tracking ability and PickMaster application software that can be programmed using a PC to carry out very rapid picking opera-

1 The IRB 340 hard at work picking cheese in a dairy plant in Scandinavia.



2 The sealed, corrosion-resistant wash-down version of the IRB 340 FlexPicker™, designed especially for hygiene-certified environments, can be cleaned using detergent and water at a low pressure.



tions on the fly. They include identifying, selecting and picking items from one or more conveyors, then placing them on another moving conveyor.

Based on the Delta¹ concept, FlexPicker is a parallel robot, which means that the main axes work in parallel with each other. The robot has four degrees of freedom and a dynamic mass of around 4 kg, excluding the handling capacity of 1 kg. Thanks to its design and the S4Cplus control system with QuickMove™ facility, the robot is capable of more than 150 picks per minute, which is more than twice as fast as a human operator.

The robot system is modular in design and can carry out picking operations with the same flexibility as a human operator, ie it can choose an object, grip it and

deposit it while in motion, for example on a moving conveyor. The wash-down variant of the robot, the IRB 340SA, is designed to work in 'open food' environments (ie hygiene-certified operations) **1**.

The system consists of the IRB 340 robot (or its wash-down variant **2**), the S4Cplus robot controller, Conveyor Tracking and PickMaster soft-ware, plus standard components such as vision cameras (for optical identification), PCs and monitors.

Main development areas

Emphasis was placed on the following during development of the FlexPicker system:

■ *High productivity* is ensured by an extremely fast robot, which in picking

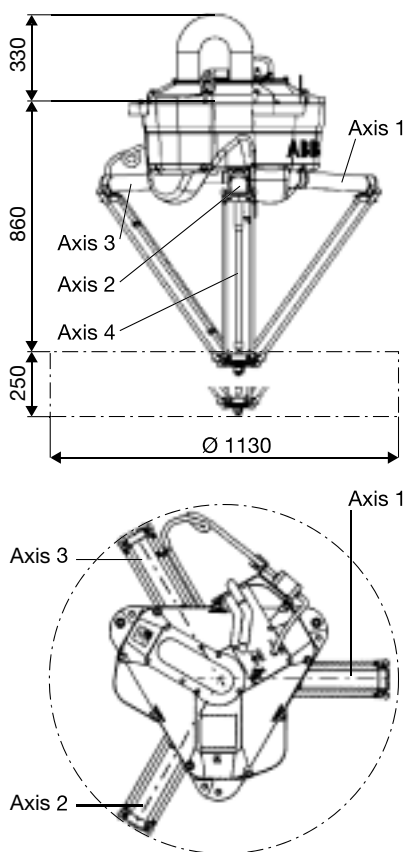
operations (ie, picking up, turning and putting down) can complete over 150 picks per minute. Its maximum speed is 10 m/s and it has a maximum acceleration of just over 10 g (>100 m/s²). The set-up time when changing to different product variants can be kept very short. The vision system and pre-programming are the key to this.

■ *Thanks to its modular design and standard options*, a FlexPicker installation can be very easily optimized for different applications. There are numerous optional application connections for the robot, including a power outlet and signal port, vacuum system and vacuum hoses. The control cabinet also offers a number of options, including Multitasking, Conveyor Tracking, ScreenViewer™ and Ethernet Services. The vision system is not connected directly to the control system, but is made up of modules that are

¹ The Delta concept is a system of movement patented by professor Clavel, EPFL, Lausanne (École Polytechnique Fédérale de Lausanne)

connected to the cameras used by the installation. The PickMaster is a newly developed, PC-based ABB product for identifying objects and picking at speed, as well as for programming rapid picking operations.

■ *Excellent availability and simple operation* are safeguarded by the modular design and by applying the



3 With its three coordinated axes, the robot picks and places items in the horizontal plane inside a cylindrical working area with a diameter of 1130 mm and a height of 250 mm. The fourth axis permits complete rotation of the item.

strict 99% availability requirement of the automotive industry to the robot system's construction. Because the PickMaster functions are programmed off-line, operation is straightforward and consists mainly of starting and stopping, along with simple corrections to the station during operation.

■ *The small space requirement and large working range* have been achieved by suspending the robot over its working area – a cylinder with a diameter of 1130 mm and a height of 250 mm **3**.

■ *Washable*. The wash-down variant is sealed to enclosure standard IP67 and painted with a specially prepared paint; all aluminum parts are anodized. This variant can be operated in hygiene-certified environments and cleaned to the relevant industrial standards.

■ *Easy to service*. The robot system is built up from modules, which ensures that no component takes longer than half an hour to replace.

FlexPicker™ with PickMaster™ – a profitable investment

The FlexPicker IRB 340 was developed to carry out extremely fast picking operations, for example in the food, pharmaceuticals and electronics industries, where single-item picking operations are frequently required **4**.

Because of the high production capacity of this system and the fact that product-associated hardware solutions for conveyors and pallets are provided by software (eg, Conveyor Tracking and PickMaster), this investment is very profitable, even reckoned by the

payback requirements of the consumer goods industry.

The fact that FlexPicker eliminates monotonous picking work – which can lead to strain injuries among operators – makes the automation of picking operations with FlexPicker even more attractive.

As flexible as a human

The robot system picks items from a continuously moving conveyor and places them on another, also continuously moving conveyor. The vision system allows the product to be identified and picked. Defective products, ie any products that have not been programmed, are therefore ignored.

Setting up production/picking for different products or variants can be done quickly since there is no need to make changes to the hardware. The changeover is handled by the software, which is pre-programmed for the new product. All the operator has to do is select another program and restart the line – less than half a minute is needed.

Picking can be carried out item by item or several products can be picked at a time using a multiple gripper, the total handling capacity (products plus gripper) being up to 1 kg.

Twice as fast as a human operator and requiring less space

With a cycle time of less than 0.4 seconds for a standard cycle of 25 x 305 x 25 mm, the robot system is more than twice as fast as a person. Its repeat accuracy is ± 0.05 mm. Because the robot is

suspended over the conveyor it also requires less space than a human operator.

Mechanical robot design

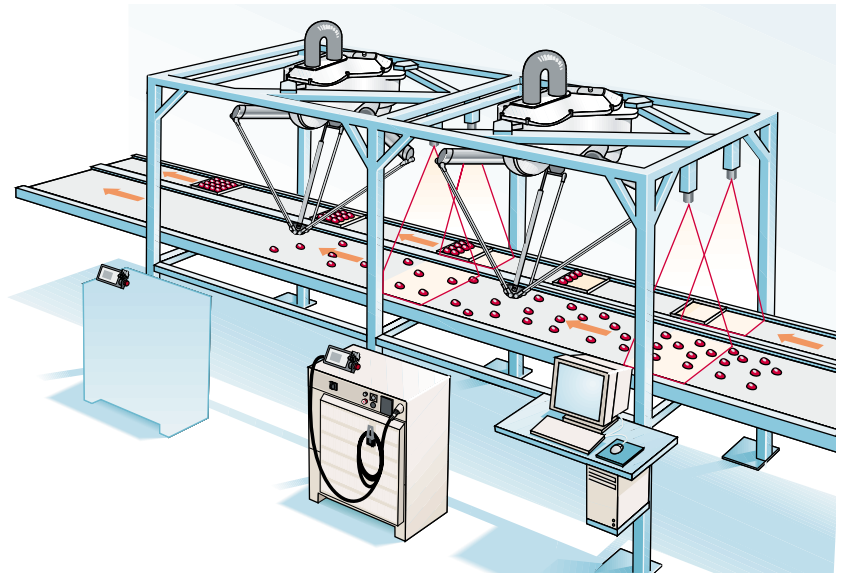
The robot has three pairs of arms, each with an upper and a lower arm, articulated at the elbow. The lower arms are joined to a tool plate which can be fitted with vacuum couplings. The upper arms are attached to a base plate through gearboxes and electric motors. The 4th axis, which is telescopic and permits full rotation, is attached to the base plate as a separate module.

The drive units are protected by a plastic cowling. To keep down the weight of the moving components and to maximize strength, the arms are made from plastic reinforced with carbon-fiber. The mounting points for joints and the gripper plate are made from anodized aluminum.

The three arm assemblies with their drive units are built as individual, but identical modules. The lower arms each consist of two rods, held together at the joints by two spring assemblies, and can be removed quickly and easily, for example to permit cleaning or replacement. The electric motors are cooled by a fan system housed in the base casing consisting of the plastic cowling, a base plate made of cast iron and an aluminum cover. Eyes in the base plate enable it to be suspended inside a portal frame.

The distinctive curved pipe above the cover distributes cooling air when internal cooling is used. If external cooling is wished the robot's air vent is

4 Sorting and collating concept with two in-line FlexPickers for carrying out pick and place operations on two parallel conveyors. Cameras are used to identify trays and biscuits. PickMaster™ application software ensures that the biscuits are rapidly placed in the correct tray.



connected to an external ventilation system.

The robot is available with a number of factory-installed application connections, such as an electric signal port and power connection to the robot's base plate, a vacuum system for suction cups, and separate air hoses for connection to an external vacuum system.

PickMaster – newly developed process software

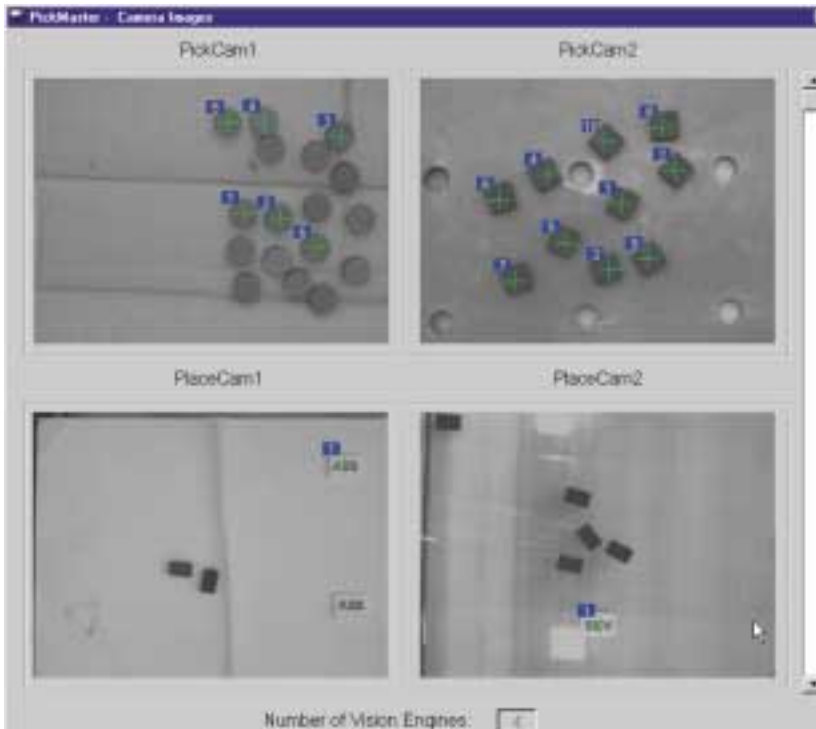
PickMaster is the name of a complete package of functions that allow the programming, control and operation of picking robots. PickMaster can be supplied in various combinations of software and hardware, depending on the specification of the cell or line and its various components. A typical robot line that can be operated and controlled by PickMaster might consist of the following parts:

- One or more FlexPicker (IRB 340) robots
- One or two conveyors for each robot, for picking or placing products
- One or more cameras for identifying and locating the position of the products on the conveyor
- A PickMaster PC, which is responsible for master control vision and coordination of the entire line.
- A local network that provides the communication link between the PickMaster PC and the robots. This network uses Ethernet.

A PickMaster integration package usually consists of the following components, but can vary according to the arrangement of the robot line:

- PickMaster application software, ie the control program that is installed and used by the PickMaster PC.

5 Screenshot of search results obtained with four vision engines



- Vision system software, ie the program that has to be installed and used by each vision server. It comprises software for image recognition, for programming models and for adjustment during operation. This software, which was developed by Cognex, is called Cognex OMI.

- A hardware card for image processing, which has to be installed in each vision server. There are two versions of this card, one for a single camera and one for up to four cameras. This card was also developed by Cognex. When several cameras are used, these can operate independently of each other.

- An I/O board for real-time triggers.
- Encoder boards for reading the conveyor and positioning speed.
- Communication software for the Ethernet link between the PickMaster PC

and the various robots, ie the robot control cubicles that make up the line.

- 'Prepared for PickMaster': this special software supplements the robot program option and is installed in each robot. The program translates the positions obtained from the various vision systems into precise and rapid robot movements.

Picking line, controlled by PickMaster

A typical robot line for picking work – in this case for handling biscuits – could be built up as described in the following. In this example, a FlexPicker robot picks the biscuits from a conveyor [4](#) on which each product is identified and located by a camera with vision system software [5](#).

The camera takes pictures that are synchronized with the motion of the conveyor, such that each section of the

conveyor is covered by at least one picture. In this way all the products, which are randomly spread across the conveyor, are detected and picked. Synchronization with the motion of the conveyor is achieved by a counter linked to an encoder on the conveyor, which keeps track of how far the conveyor has moved, and at preset positions sends a synchronization pulse to the camera, which then takes a picture.

The picked products have to be placed in trays at specified positions and in a specific order. These trays are placed individually, ie one at a time, but randomly, on the outfeed conveyor.

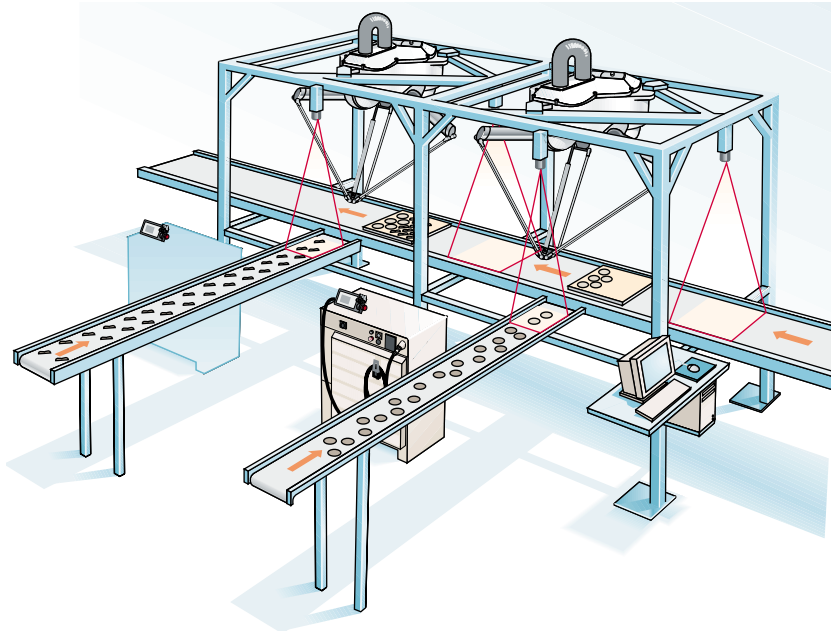
Another camera determines the position and orientation of each of the trays. A new picture is taken every time a tray passes an optical sensor, ie when it breaks a light beam across the conveyor. The PickMaster system then keeps track of the free positions in each tray where it can deposit the biscuits.

Simple configuration and operation of a picking line

As the above example shows, a typical line for pick and place operation can be complex, comprising robots, cameras and vision systems. All of these different elements have to work together in harmony to give the desired result, as on a line for filling boxes with a selection of chocolates [6](#).

PickMaster has a number of powerful features for controlling such lines. It is, however, far from enough just to be able to control a line during normal production, when everything is going to

6 Mixing concept with two in-line FlexPickers for picking chocolates from infeed conveyors and placing them in trays on an outfeed conveyor. To allow items to be quickly identified and placed in the correct position in the tray, this solution also uses cameras and PickMaster software. Programming is carried out in a Windows environment on a PC.



plan. What is also necessary is to be able to install a line quickly and easily, and then keep it in operation when changes are made in production or while problems are being corrected. This means that its operation and the operator's controls must be simple and intuitive to minimize the risk of faulty operation.

Installing and programming such a complex line can be a time-consuming business using conventional methods, which normally include the following steps:

- Installation and commissioning of software on the various computers and robots.
- Configuring network communications, ie each connected unit, such as a robot, must be identified and described.
- Description of conveyors. The conveyors that each robot has to work

on must be described and calibrated, ie their positions and orientation must be measured.

- Description of cameras used and how they are connected to the system. Translation or calibration of image information for robot units **7**, ie in terms of position and orientation that the robots' coordinate positioning system will understand.
- Description of the various products that the robot will work with and which have to be recognized by the vision system.
- Teaching the vision system to recognize the various products and how they should be gripped.
- Description of how the input of pick and place positions generated by different cameras should be assigned to the different robots, and in what order.

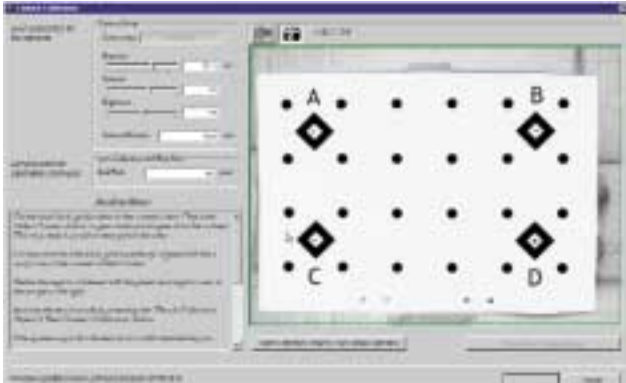
- Programming and configuring the various robots with their sequence of movements for the various picking operations.

PickMaster shortens the time needed to do this work to just a few hours, thereby reducing the risk of errors and damage.

The software features a number of 'wizards' for configuring the cell which guide the user through a sequence of dialogs, prompting with various questions and offering alternatives to suit specific needs. Tasks handled by the wizards are:

- Configuration, ie describing the components of the line.
- Calibration, ie measuring the conveyor and camera positions, so that all necessary dimensions and positions can be entered in the robot's coordinate system.

7 Calibration of cameras and robots is supported by PickMaster wizards.



8 PickMaster Operator's Panel for fast production change-over and for controlling and monitoring a robot line during operation



- Model description, ie teaching the vision system to recognize various products.
- Definition of the picking operation from camera picture to robot positions.

Once the configuration has been defined using these tools it can be displayed in the form of a schematic tree that illustrates the various components and their relationships.

It is not only during the installation and programming that simple tools and operational support are needed. They are equally important when a line is running, for handling problem situations or when setting up for different products. For handling such situations, PickMaster provides two further powerful tools:

- Project Viewer
- Operator's Panel

The PickMaster Project Viewer is designed to help the robot programmer check, modify, remove or add components or operations to an existing picking line.

Using the PickMaster Operator's Panel **8**, the operator can start and monitor a line during production. It lets the operator gather information about the status of various parts of the line, view error codes and suggested corrective measures, stop and start the line or individual robots, check individual cameras, etc.

S4CPlus controls the world's fastest robot

S4CPlus **9** is the latest in a series of control systems for robots. It builds on a tradition of reliability, robustness, ease of operation and unique, sophisticated control of motion at unsurpassed speed. In comparison with its predecessor, S4C,

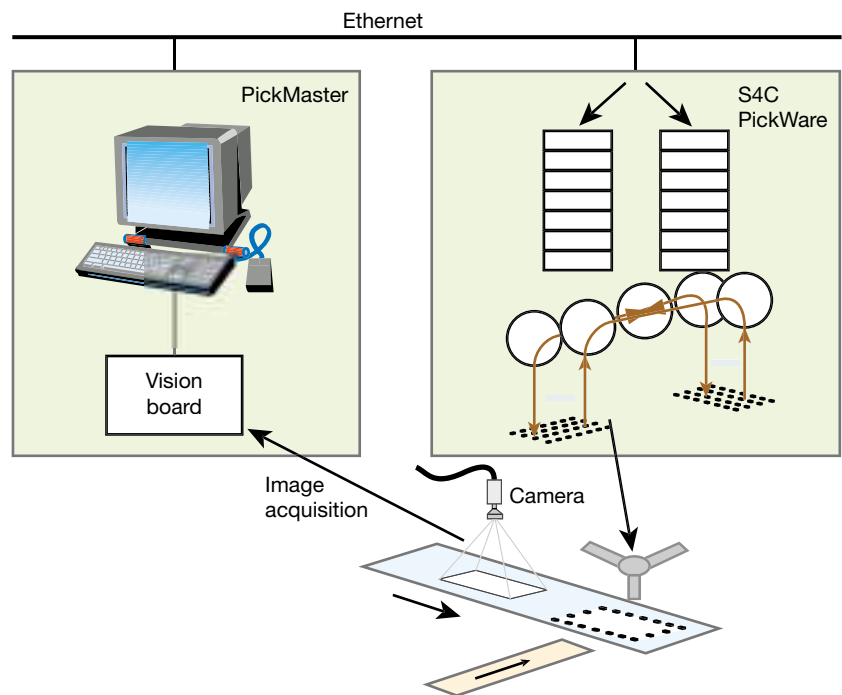
S4CPlus offers the following new functions and features:

- S4CPlus exploits a new internal computer system based on Pentium processors and uses PC-compatible units that are connected to a PCI bus.



9 The new S4CPlus control system is based on PC technology for industrial applications.

10 Data flow for a pick and place operation. PickMaster receives position information from the camera and vision system, which is then sent to the respective robot's position buffer. The sequence in which each robot moves is given by the pick and place buffers.



- Increased processor capacity and improved performance permit faster and more accurate robotic control.
- New memory architecture with hard disk and greatly increased memory.
- New communication links, based on Ethernet and USB, as standard.
- Increased flexibility permits the use of commercially available units that can be connected to a PCI bus.
- More efficient diagnostic routines and correction of faults using test routines on a PC connected directly to the system.
- A specially adapted control cubicle.

S4CPlus is just as easy to use as its predecessor, S4C, since the same programming language, RAPID, has been used to describe the movements and other functions of the robot, and the same programming unit with interactive

operator functions is used for programming and operation.

Control of the robot's movements is based on the same unique software with its sophisticated modeling of the robot's characteristics, which ensures optimum path-following, regardless of load, position or programmed speed.

Control of movement is based on QuickMove™ and TrueMove™ techniques; the former ensures that movements are executed at a speed close to the physical maximum, and the latter that it is done with the specified high path accuracy.

Prepared for PickMaster

'Prepared for PickMaster' is the special software that has been developed for FlexPicker robots, and which is used by lines controlled by PickMaster. This

means that no real programming is required for the robot itself, since all movements are predefined for each pick and place operation, and no further information is needed other than that generated by PickMaster.

A typical pick and place operation is shown in 10. The robot receives its pick and place positions from PickMaster, and these are stored in an internal buffer by the robot system. The robot moves to a position above the picking location and then synchronizes its movement with the motion of the conveyor. The robot then moves down to the pick position while tracking the conveyor. The robot grips the item by switching on suction, waits a short while, rises, then moves to the outgoing conveyor, with which it now synchronizes its movement.



11 Incorporated in a FlexWrapper™ packaging machine, an IRB 340 picks and places finished, customized cartons.

Once above the place position, the robot drops down, places the item and releases it. After another brief delay it rises and repeats the cycle.

Fast and flexible solutions

Installing FlexPicker with PickMaster ensures the excellent performance needed to make automating picking operations a profitable investment. And FlexPicker is suitable for a wide variety of applications, in fact everything from preparing assembly pallets in the electronics industry, through pick and place operations and packaging in the food industry, to packing medicines in the pharmaceutical sector **11**.

With its exceptional speed – in excess

of 150 picks per minute – and better than 99% availability (as demanded, for example, by the automotive industry), very high production capacities are ensured.

PickMaster and its vision system ensure that the robot system finds unsorted products, that it can be quickly reset to pick other products or variants, and that it can be programmed off-line in a Windows environment.

Servicing and maintenance of the compact system are carried out quickly and easily thanks to its modular design and straightforward mechanical and electrical interfaces.

In short, FlexPicker with PickMaster revolutionizes the automation of picking

operations on conveyor belts. What is more, the benefits it offers the consumer goods industry can easily be extended to other branches of the manufacturing industry.

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Reference

[1] E. Hemmingson, H. Brantmark: Palletizing robots for the consumer goods industry. ABB Review 4/98, 17–24.