

Palletizing robots for the consumer goods industry

FlexPalletizer IRB 640 is the name of a new palletizing robot developed by ABB that meets the special needs of the consumer goods industry, and particularly those of the foodstuffs and beverage sector. 1,200 palletizing cycles per hour and a handling capacity of 160 kg are among the performance features that ensure fast pay-back of the capital investment. Modern software tools not only increase productivity but also lower the cost of operating the robot. PalletWizard, for example, allows users to create their own palletizing programs off-line and requires no special knowledge of programming. It works in a PC environment and allows the robot to be kept in production while new work cycles, etc, are being created.

The immediately recognizable feature of the FlexPalletizer is its curved upper arm. Other characteristics of the robot are a comparatively small number of axes (four) and a system of levers that keeps the rotary disc of the 4th axis parallel to the horizontal plane **1**.

The new IRB 640 robot system for palletizing operations has been designed with features that take account of the special circumstances existing in the consumer goods industry, etc, where the hourly rates for the workers are only half of what they are, for example, in the automotive industry. These incorporated features satisfy a whole range of important requirements:

- Drastically reduced first-time costs; the simple design of the four-axis robot, which is tailored precisely for its intended fields of application, as

well as many other overall system characteristics, reduce costs considerably.

- Significantly increased productivity; much shorter cycle times and a 25 to 30 percent increase in handling capacity over earlier robot designs are the primary reasons for this. Also important is the fact that the palletizing programs can be written off-line. The robot can therefore be kept in production while new work cycles are being created.
- Simple, time-saving programming that makes only modest demands on the

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user; PalletWizard is a software tool, developed by ABB, which provides a graphic user interface for creating palletizing programs quickly and easily. No special knowledge of programming or computer technology is required.

- Compact system offering maximum flexibility, safety and reliability; the IRB 640 palletizing robot exhibits an availability of up to 99 percent. Due to its space-saving design, it can also be installed in rooms with low ceilings. The versatility of the robot enables companies to adapt it to new operating conditions quickly and at low cost.

High productivity and precise movements in a large work envelope

A handling capacity of 160 kg and up to 1,200 work cycles per hour makes the FlexPalletizer one of the best-performing robots available on the market today.

High-precision for the sequence of movements is of utmost importance. The path of a robot is defined, for example, by the radius of the reach to the corner zones, plus the vertical and horizontal displacements. A function called TrueMove ensures that the robot follows exactly the programmed path, irrespective of the speed that is chosen.

The robot system features a remarkably large work envelope. For a pallet 1.20 x 1.25 m in size and up to 2.10 m high it extends in axis 1 over the full angle of rotation of 360°. Even with the lower arm in its maximum bend-back position, the effective work area remains completely free within the total angle of rotation **2**.

The large work envelope and the high handling capacity enables the robot to be



IRB 640 FlexPalletizer – the articulated system holds the rotary disc parallel to the horizontal plane, thereby replacing the otherwise usual but complex bend-back function and the wrist axis.

installed in the widest range of physical configurations. Due to its compact, space-saving construction, the robot itself is only 2.20 m high (with the upper arm lying horizontally), enabling it to be operated in low rooms.

**High availability,
safe operation and simple
monitoring**

The high availability of the FlexPalletizer is achieved by using mainly components from the tried and tested IRB 6400 ro-

bots. Special attention was paid during its development to operator safety, for example by equipping the robot control system with a two-channel safety system featuring status signals for both channels. Safety is further enhanced by conveniently positioned emergency stop buttons and the three-position enabling switch.

The control system of the FlexPalletizer features several generic functions for monitoring production and execution of the program. To these belong safety functions, an integrated trouble-shooting function which makes automatic re-starting easier after faults have been corrected, and a facility for connecting the installation to a central computer in order to monitor its operation. A programming unit makes it easy to check the current status of the work on-line. With the help of interactive functions the operator can be kept informed about the products, palletizing cycle, and manual corrective action to be taken in the event of disturbances.

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Compared with conventional articulated-arm robots with six axes, the FlexPalletizer has a comparatively simple construction. Cases are placed on pallets, for example, parallel to the horizontal plane; there is no need for twisting of the upper arm. The bend-back function

of the wrist has been replaced by a system of levers which holds the rotary disc of the wrist drive in a horizontal position throughout the work envelope of the robot **2**, **3**.

The compressed air and control connections are installed for the 1st to the 4th axis. In addition, the robot has been prepared for the installation of a vacuum system for grippers. Electrical connections for a vacuum pump and the vacuum piping are also provided.

Optimized for palletizing and packing

The FlexPalletizer is designed to handle cases, crates, bags, etc, in short all the items used in the foodstuffs and beverage industry. The robot is also well suited for use in combined palletizing/depalletizing stations **4**, where it can customize a new pallet from three different pallets, while simultaneously serving magazines for pallets and tier sheets.

5 shows another application, in this case a simple station for end-of-the-line palletizing. Here, the FlexPalletizer serves an infeed roller conveyor carrying bags which are to be palletized, as well as a magazine for pallets and one for tier sheets. An exit roller conveyor automatically removes the finished pallets.

The extremely high performance capability of the system enables it to serve up to five palletizing stations working from four different infeed conveyors. The products being handled may be stacked to a height of 2.10 m.

Another feature of interest to the consumer goods sector is the robot's capability for rational packing of products in cases, boxes and crates. High-speed robots equipped with vision systems for identifying objects are the ideal solution for such applications.

Investment costs are paid back quickly

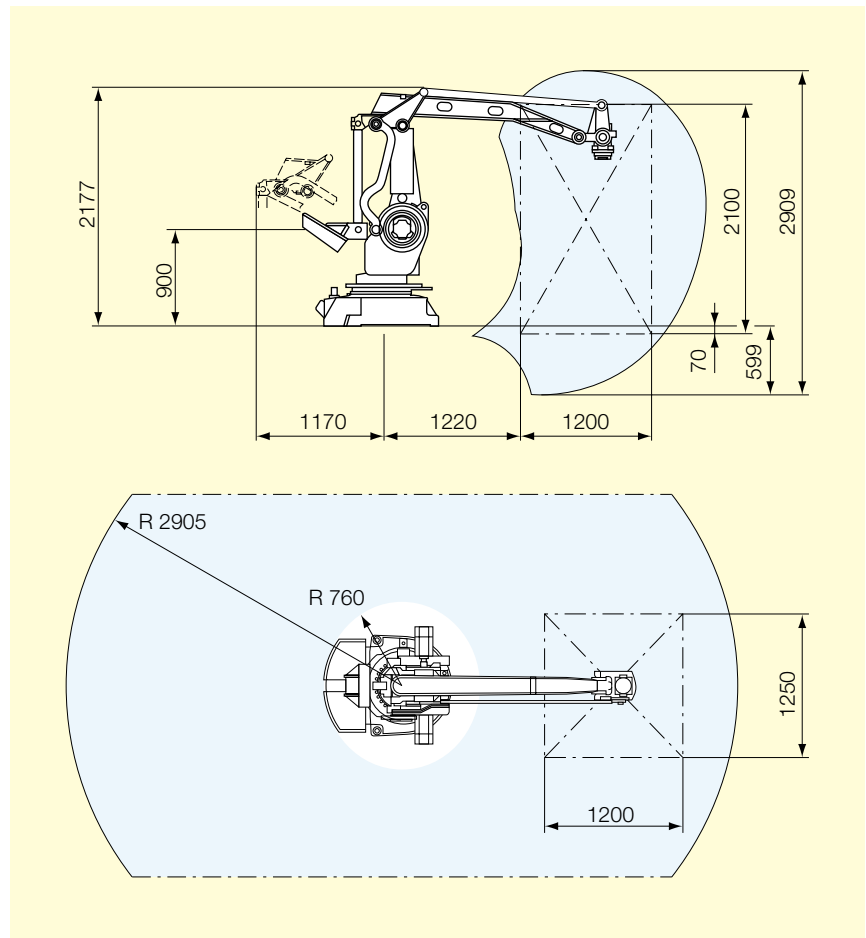
The FlexPalletizer is intended for use in industrial sectors needing to install automated plant to become more competitive, but which also have to keep the investment volume down in order to reach profitability goals. The system satisfies these boundary conditions by significantly reducing the cost of the investment while offering broad performance capability. This capability includes suitability for a wide variety of applications, stable performance, exceptionally high availability and productivity, low demands made on factory space and personnel resources, plus a high level of standard-

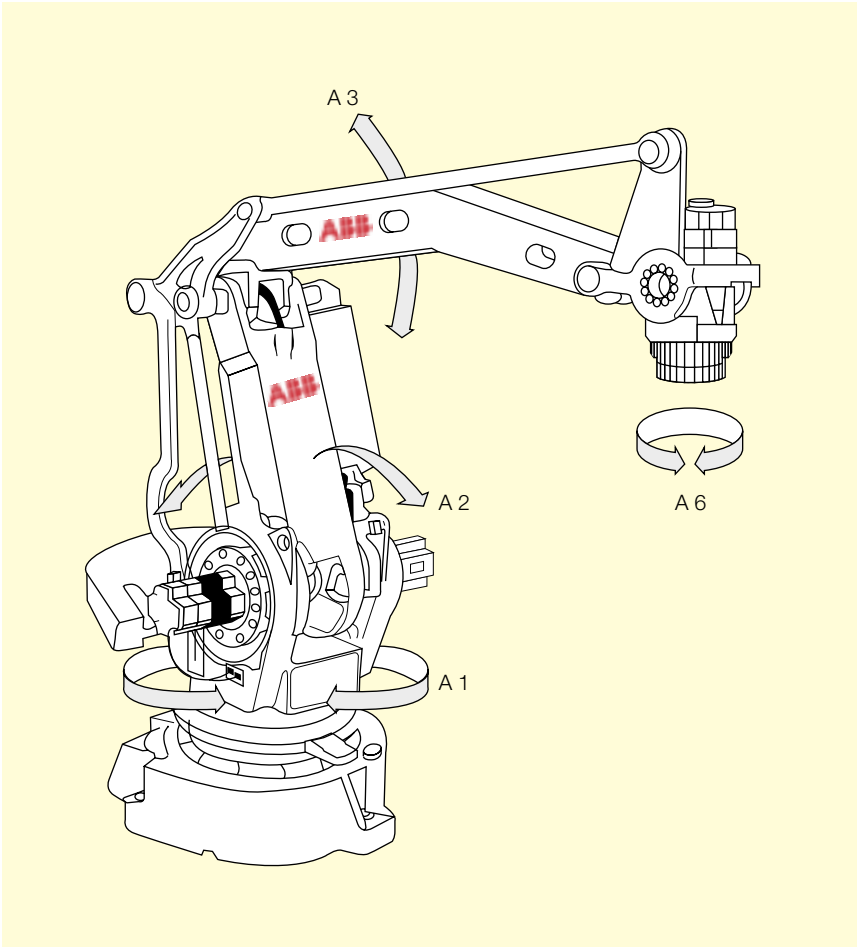
ization in even the most complex palletizing stations. What is more, experience has shown that after three years of operation the system still has a resale value equal to about 65 percent of the original investment. Another important factor is that the risk of injury to personnel when lifting heavy boxes and bags, etc, is banished as the robot easily handles weights of up to 160 kg.

S4C – a proven controller for ABB robots

The 'brain' of the robot system is the new but well-proven S4C control system [1]. This controller, which is now being in-

Work envelope of the FlexPalletizer. The radius in the horizontal plane is 2.9 m and in the vertical plane up to 2.3 m. The compact design of the IRB 640 is a special benefit for applications in rooms with low ceilings. The robot follows the programmed path with high precision.





The FlexPalletizer requires only four axes (A1, A2, A3, A6). This simplification has resulted in a significant cost-saving that benefits both the capital investment and operation. A large work envelope, a handling capacity of up to 160 kg and a performance of 1,200 cycles per hour are outstanding characteristics of this robot system.

stalled in all ABB robots, features a newly developed programming unit and makes use of the robot language RAPID. Benefits of the controller include compactness, high functional reliability and a high level of flexibility **6**.

Hardware and communication

At the center of the system is the microprocessor-based control electronics that guarantee the high performance of the robot. Data is exchanged with other systems either over high-speed, serial interfaces or a LAN link (eg, Ethernet). A CAN bus is used for the

communication with the distributed I/O units.

Programming unit

The operator can access all the system functions via a lightweight, portable programming unit. Only a few buttons need to be pressed to program even complex functions. The semi-graphic user interface guides the operator by means of menus.

Programming

To increase productivity and simplify programming ABB developed special software products, such as PalletWare and

PalletWizard. With the help of these tools, the robot programs can be created off-line on a conventional PC. Operation of the robot is unaffected by this. The person doing the programming requires no special knowledge and only needs to be familiar with the use of a PC and with the Windows environment.

Motion control

Perhaps the most important property of a robot is optimized motion control, since this directly influences the cycle times and the accuracy of the process. With their unsurpassed combination of speed and precision, ABB robots are the international leaders in this area.

PalletWare

A typical robot workcell for palletizing can comprise an IRB 640 FlexPalletizer, up to five different pallet stations, infeed conveyors and stacks of empty pallets or tier sheets **7**.

The robot first takes an empty pallet from the stack and places it in a pallet station, afterwards picking up the products from the infeed conveyors and placing them down in layers on the pallet according to a given pattern. To stabilize the stack products, tier sheets made of paper, cardboard or plastic can be placed between the individual layers. Use of different palletizing patterns is another method employed to stabilize the stacks.

PalletWare is the new process software used to control the palletizing robot doing this work. It was fully developed using the standard RAPID programming language for ABB robots and can be viewed as an operator interface. The following four features were fully implemented in its functionality:

- **Flexibility:** The palletizing station has to be quickly and easily modified

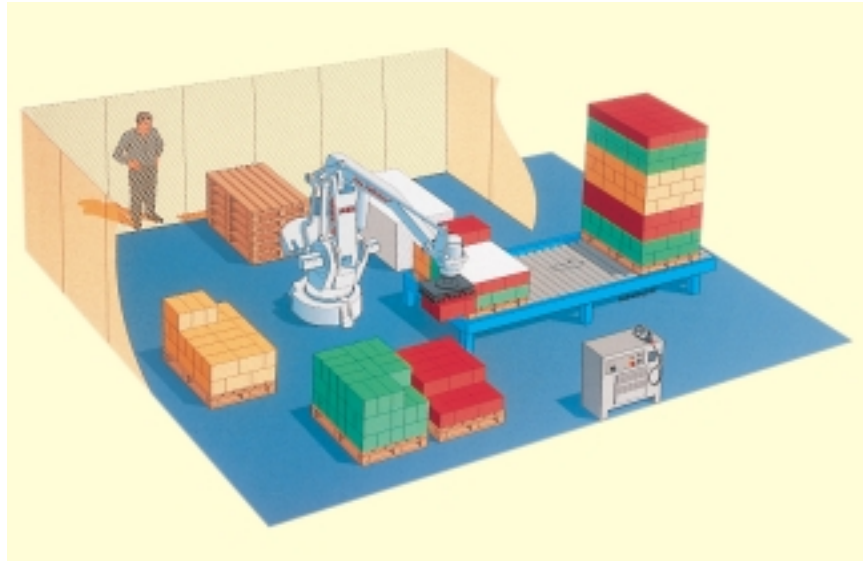
whenever changes to the operating sequences, involving the products, in-feed conveyors, stacking stations or stacking arrangements, become necessary.

- *Tolerance:* The system must be capable of compensating for fluctuations in the process, eg slight changes in the size of the product.
- *Performance:* The software must ensure short cycle times and precise path-following.
- *Variability:* It must be possible to quickly develop and deliver customized palletizing cells. The design of the software must support this requirement.

Unlike most robot programs, PalletWare does not work with fixed-programmed positions. Instead, the local positions of the different stations, ie the infeed conveyors and pallets, are defined. The program calculates on-line the actual positions where the products are to be picked up and put down. The data necessary for this (eg, the number of layers on a pallet, the layer configuration or the pick/place operating modes) can be entered manually, although the idea behind this software is that it should be used together with the brand-new programming tool, PalletWizard.

PalletWizard – a new programming tool

PalletWizard is a software tool with which users can quickly and easily generate all of the data needed to control the robot for every new palletizing job. The user has only to be familiar with the workings of a PC; no real knowledge of programming is necessary, neither does any programming have to be undertaken on the robot itself. All of the programming work is performed off-line on a conventional PC. When the programs are complete they are trans-



The FlexPalletizer is customizing a pallet from three different pallets. The robot also serves magazines for pallets and tier sheets. The finished, customized pallet automatically exits on the roller conveyor.

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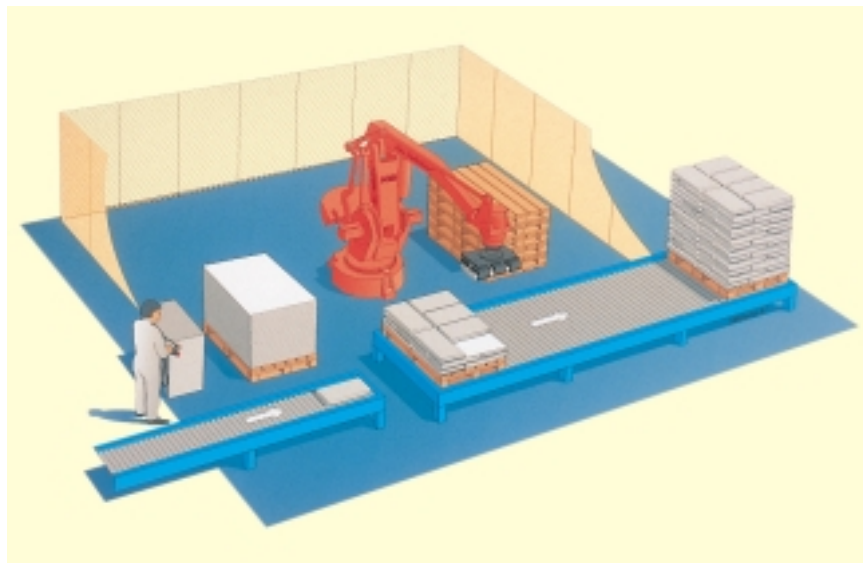
ferred as RAPID modules from a diskette or via a LAN link to the robot control system.

Providing a small number of preparatory conditions are fulfilled, PalletWizard can be used to completely reprogram a palletizing cell. The reprogramming can take account of new products, pallet patterns and layers, new combinations

of pallet stations and infeed conveyors as well as all types of pick/place operations. The preconditions include measurement of the physical location of the different stations and calibration of the tools that will be used. In addition, a number of user-routines have to be programmed for the communication with the peripheral equipment.

The FlexPalletizer serves an infeed roller conveyor for bags about to be palletized as well as a magazine for pallets and one for tier sheets. In addition, there is an exit roller conveyor for the finished pallets.

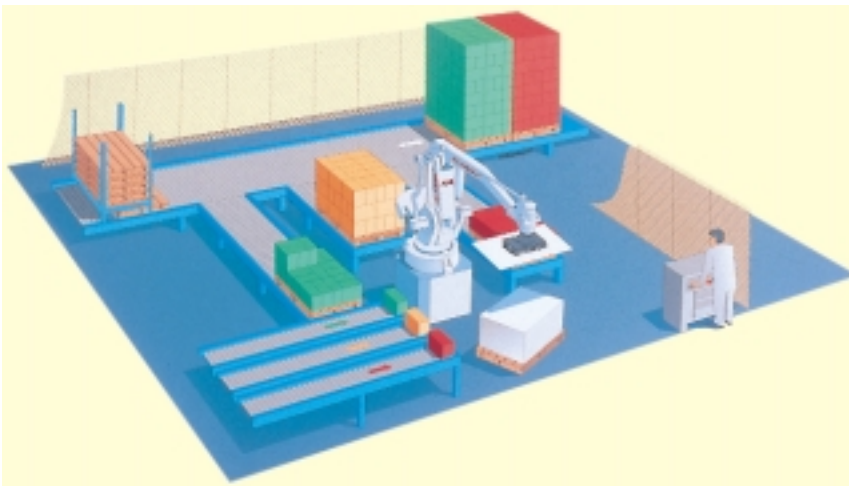
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Robot control system S4C. The functions of the system can be fully utilized by means of a Windows-based operator interface and buttons on the new programming unit.

Typical palletizing workcell with three infeed conveyors and three pallet stations (up to five are possible). The robot additionally serves stacks of empty pallets and tier sheets.



When PalletWizard is started five different windows first appear on the monitor, each representing an important element in the process **8**.

Advanced operator-interface

The present configuration of the palletizing cell is shown in the middle window, in which icons represent the stations and the robots **8**. The operator can click a station icon to open another window that shows the properties of the station, which can be modified. Typical properties are the maximum height or the type of user-routine employed when the robot goes to or leaves a station.

A list in the top-left window gives all the stations, the robot itself and its tools. The configuration of the cell can be easily extended by adding pallet stations, infeed conveyors and stacks. The properties of the stations can be modified accordingly. The user can define which and how many products the different tools have to pick up and which gripping zones are to be used. **6**

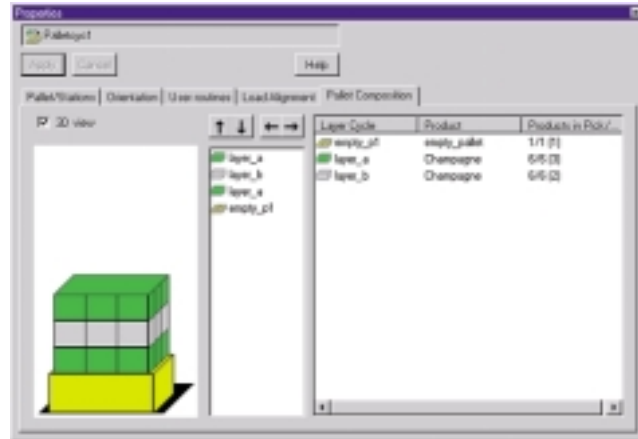
The objects to be moved by the robot are given in the bottom-left window, which also lists the empty pallets and tier sheets. Additional information includes the dimensions of each product, the side on which the label is fixed, the handling speed, and how the robot has to pick and place the product at the respective locations. **7**

The window at lower right gives the available user-routines. For example, there is a special routine which starts a sensor that checks whether all the products have been picked up, and subsequently gives orders on the basis of the result. The user can adapt these routines as necessary.

The window at top right is used for operations involving the pallet cycle.



Five windows appear on the screen when PalletWizard is started. The middle window shows the workcell configuration, with icons representing three pallets and three infeed conveyors, plus a stack of empty pallets. The robot is also represented by an icon. 3



Screenshot showing a three-layer pallet. Colours show the operator which layers have the same pattern and which layers have different ones. 9

Defining pallet cycles and layer patterns

A complete pallet cycle involves an empty pallet being picked up, products being placed on it in several layers, if required with tier sheets inserted, and the stack being covered with a protective material.

The robot is capable of working simultaneously in several cycles. In such cases it works alternately with one or the other pallet, however always first ending the pick/place operation currently in progress before moving to the next pallet. Each of the cycles can be individually structured and defined on the screen.

A pallet normally consists of several layers of products, which can be all the same or varied. The products are placed in a certain arrangement in each layer. This so-called layer pattern can change from layer to layer.

When programming the layer pattern, the layer can be given for each station and it can be defined exactly where the product is to be put down and how it should be aligned. It can also be defined how many products the robot has to pick

up in all during each pick cycle, and whether it should place these products individually or in groups.

The operator interface offers windows especially for defining the composition of the pallet, the different layer patterns for the products, and the pick/place operations.

The pallet composition window models a complete pallet together with all of its layers. The program allows pallets to be composed as well as modifications to the number and sequence of the given layers. Different layers having the same pattern are shown with the same colour for easy identification 9. It is also possible to determine the pallet station involved and how the product stack is to be arranged on the pallet, ie centered or aligned with the sides.

Layer pattern

The user can freely define the pattern for the products in each layer. The model on the screen first of all shows an empty pallet. Vertical and horizontal reference lines are drawn in to define the physical location of the products. The user then chooses a pair of lines, one horizontal

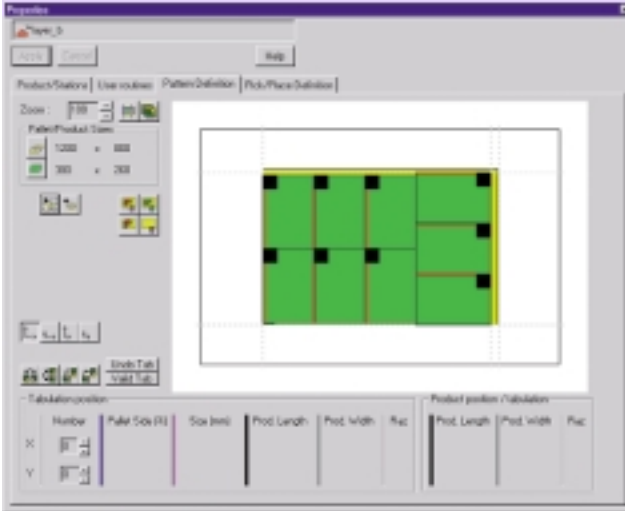
and the other vertical, and positions the products in relation to them. By clicking buttons in the bottom bar on the screen the user can adjust their exact position along the x-axis and y-axis; in addition, they can be turned or rotated into the desired position 10.

By choosing different reference lines for two products, the user can create space between them. This will ensure that there is no risk of overlapping whenever the dimensions of the palletized objects change during the working process.

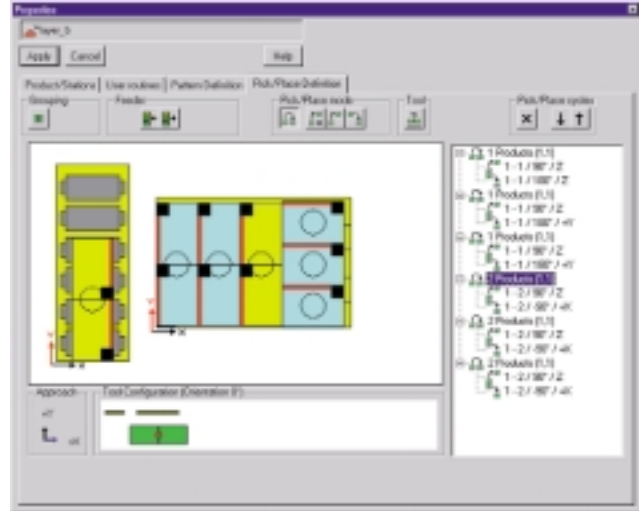
To make the operator's work easier, pre-defined patterns can be selected which are automatically adapted to the dimensions of the respective product.

Pick/place operations

The robot is able to pick up products individually or in groups in the form of load units, which are represented on the screen by circles. The load unit, in turn, can be placed in position by the FlexPalletizer either in a single operation or piece by piece. A separate window can be used to define the detailed sequence of pick/place operations 11.



Objects can be aligned exactly in the x-axis and y-axis with the help of reference lines. Rotation into the desired position is also possible.



Representation of an infeed conveyor with the products to be picked up. Circles indicate load units which can be moved in single pick/place operations.

The screenshot shows on the left a symbolic representation of the infeed conveyor and on the right the pallet with its layer pattern. In the example shown the pallet layer, which consists of nine products, is divided into six load units, three of which comprise one product each and three two products. Six pick/place cycles are therefore necessary to palletize these products. The window on the right of the screen gives a list of these cycles, which are shown both as pick and place operations. The alignment of the products can be chosen freely, making sure that the side with the label and red edge lies in the desired direction.

Easy-to-use program code

When the complete pallet cycles have been entered and the workcell has been defined with all of its components, data modules are generated for the robot system. These modules can be transferred to the system either from a diskette or via a link.

The generated data modules for the new work procedures can be employed directly on the robot. If necessary, the

operator can change the dimensions of the product at a later date with the help of the programming unit, in which case the system automatically carries out the adjustments in the stored layer patterns.

A range of benefits with robot-based palletizing

Palletizing robots offer industry a wider range of benefits than other technologies. A robot, besides featuring high availability, is more versatile than any other automated machine. Robotized automation of pallet handling increases production capacity and flexibility while also improving the quality of the finished pallets; damage to products is minimal.

Human operators also benefit from the lower risk of injury, the accident prevention safeguards that are incorporated, and the improved working conditions.

Another important advantage is that ABB can deliver standardized peripheral equipment for complete FlexPalletizer systems. This includes grippers, infeed conveyors for products, exit conveyors

for finished pallets, magazines for tier sheets and empty pallets, plus protective fencing.

Reference

[1] E. Hemmingson, S. Ellqvist, J. Paulwells: New robot improves cost-efficiency of spot welding. ABB Review 3/96, 4-9.

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