Picking a winner and packing a punch

The second-generation FlexPicker™

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The demand for new automation solutions in industry is great and nowhere more so than in the packaging industry. Traditionally, picking and packing has been labor intensive. Often, a range of assorted products are packed at high speed into boxes, trays or blisters. The high pace of the process using manual labor can result in production bottlenecks affecting throughput. Employee health problems can also develop as a result of the highly repetitive nature of the work.

Automation is an attractive alternative and picking and packing robotic solutions represents one of the fastest growing markets in the automation industry. ABB already has an installed base of over 2,500 delta robots, specifically designed for this type of application, and it is a world-leader in picking and packing technology. The newly developed second-generation FlexPicker™ will ensure that ABB remains at the forefront of this industry, helping customers to improve their productivity.

The packaging industry has for decades used manual labor for picking and packing products into boxes, trays and blisters. A typical application is packing mixed chocolate pralines into blisters, a repetitive task that is performed at very high speed. This type of work is tedious and generally poorly paid, which makes it increasingly difficult to find and retain labor 1. Additionally, growing concerns about food safety have encouraged the industry to seek alternative ways to pick and pack food, so that human contact is minimized. For these reasons, the industry has shown a great deal of interest in automation.

In the late 1990s, robots were generally designed in a serial manner. One part of the robot was attached to another in a sequential fashion and each part carried the weight of its own motor. This resulted in robots with heavy arms and slow product handling speeds, unable to compete with laborers capable of accomplishing 60 to 100 cycles a minute.

1 Picking line with manual labor

2 IRB 340, a parallel arm design

The ABB FlexPicker

ABB launched the FlexPicker IRB 340 in 1998. The FlexPicker is a delta robot[1)] uniquely designed for the picking industry, to pick and pack small lightweight objects such as chocolates. The design principle was quite simple: All the moving parts were made of lightweight materials, such as carbon fibers, anodized aluminum and plastics. The heavy motor components were all placed in a rigid, non-moving base box. All the arms were linked in parallel with three degrees of freedom and joined at the delta plate. A theta axis was added through the delta plate to give the robot an additional degree of freedom. With such a configuration, the FlexPicker was aptly nicknamed "the spider robot" 2. Even though the arm system is lightweight and looks fragile, it is extremely robust thanks to the high mechanical strength-to-weight ratio of the construction material. The lightweight arms of the robot can accelerate up to 15 m/s² and reproducibly achieve an accuracy of 0.1 mm.

ABB is the market leader in delta robots with a well established reputation for quality and reliability, satisfying the needs of the picking and packing industry.

Although the robot had a simple design and was easy to build, controlling it was altogether more difficult. High-speed movement was achieved relatively easily with small motors. Far more challenging was moving the robot at such speeds without causing jerky movements or destroying the manipulator. ABB was well placed to overcome such a challenge, since its advanced motion controller was superior to its competitors' for standard robots and this technology was capitalized upon during the development of the picker. The result was the highly successful IRB 340, which can pick and place products quicker and more gently than any other robot.

Developing a market

The packaging industry is huge and fragmented. There are more than 25,000 food plants globally and large multinational food companies like KRAFT Foods and Nestle, despite their size, hold less than 5 percent of the market share. The companies selling packaging solutions are also numerous and fragmented, which presents an obvious obstacle to ABB, when seeking efficient sales channels to the customer.

From the outset, ABB's strategy was to sell products rather than complete solutions or installations. It was perceived that the most effective strategy would be to sell products to existing system integrators and machine builders who were already active in the packaging industry. The objective was to create a demand for ABB's robot-based automation within a market that already had well-established alternative solutions. The challenge was not only to sell ABB robots to system integrators, but also to create market awareness, so that the end customer would demand robot-based solutions. This endeavor started to yield returns in 2003, five years after the initiative was launched, and now grows annually by 30 to 40 percent. Today, the FlexPicker robot is sold mainly to the food, pharmaceutical and solar-cell industries.

Second-generation FlexPicker

Ten years after the introduction of IRB 340, ABB has launched the IRB 360 – a second-generation high-speed picking robot 3. The timing for this launch was good, since the market was eager for a new picking robot. The new model satisfied this demand and even provided solutions for new applications, creating new markets, which in turn have boosted sales.

An important factor influencing the timing of the launch was that the original patent, which prevented competitors using parallel arms in their robots, was no longer valid. The European patent expired at the end of

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1) A delta robot consists of three arms connected by universal joints to the tool interface. The arms form a parallelogram, which maintains the orientation of the tool interface.

2006 and the US patent at the end of 2007. Now anyone can build a delta robot and compete with ABB. In this highly competitive industry it seemed obvious that other companies would immediately start building delta robots. ABB's competitive advantage would now have to rely on its long experience building these robots, its well-established reputation for quality and its large market share reflected by its large sales volume. To remain market leader in this technology, ABB's strategy was to improve upon the advantages of the old FlexPicker, so that the new FlexPicker could carry higher payloads and target new branches of the packing industry. Improvements in the design and strength of components created a more durable and robust robot that required minimal maintenance to achieve maximal operating time.

Additional design features have made the new-generation delta robots more versatile; a smaller version taking up less space on the factory floor and a new version for the food industry that allows thorough cleaning using standard industrial methods. Of course the simple delta robot concept is relatively easy to recreate and now many companies have designed their own prototypes. The question is, how good are these new competing delta robots? Could they be good enough to reduce ABB's market share and cause the potential loss of ABB customers?

One of the most important features of the ABB delta robot is its advanced motion control, which is fundamental to the overall performance of the machine. It is easy to build a delta design robot and incorporate a high-torque motor to move it very quickly. The challenge is to make it fast and accurate, while maintaining a long lifespan. The problem is that it is not possible to compensate for poor motion control with a "stronger" mechanical design, since the weight of the robot slows its movement. High performance comes from advanced motion control. The control loop in the ABB robot controller plans the movement of the manipulator, taking account of its dynamic behavior to reduce mechanical stress.

3 FlexPicker IRB 360 launch at PackExpo, October 2007 in the USA

The benefits of advanced motion control were illustrated when ABB won an order made by a Swiss pretzel producing company. ABB beat the competition, winning the order because the ABB delta robot could pick and place the pretzels at high speed, while reducing the scrap rate from 12 percent to 4 percent. The ABB motion control is suitably named QuickMove™ and TrueMove™. The IRB 360 has been developed using the newly released second-generation QuickMove and TrueMove motion controller, which have allowed significant cycle-time improvements. On average, the IRB 360 is 20 percent faster than the IRB 340, with the best results for payloads of between 1.5 and 3 kg.

Inevitably, during the picking and packing process, products occasionally appear on a picking line in unexpected places. Sometimes frozen products, for example, can be frozen together and then separate during movement, or products can be repositioned during a sudden conveyor belt shutdown. Such product relocation can cause problems for a robot, resulting in unexpected collisions. With the FlexPicker, the lightweight arm system detaches during a heavy collision. The arm system is held in place by a spring unit that protects the arm from damage during a mechanical impact, even when fully accelerating. This safety feature protects the robot, but customer feedback suggested that a robot that stops mov-

ing when the arm system falls off would further protect the product and the conveyor. The new QuickMove and TrueMove motion controller can now detect a malfunctioning arm system and automatically stop the robot. This feature is unique to ABB delta robots and will support ABB's leading position in high-speed picking.

One of the most important features of the ABB delta robot is its advanced motion control, allowing rapid, smooth, precise and reproducible tool movement.

A robust robot

A high-speed picking robot can typically make 130 pick-and-place operations a minute. In a production line made up of eight robots, this equates to over one million cycles a day, and over 200 million cycles a year. Even with a low failure rate of one in a million, the probability of a malfunction becomes a daily event. Such a failure rate is unacceptable and can be reduced only by making the robots extremely robust. Universal joints, theta axes and fixation screws are critical elements that had to be improved. Components have been made stronger so that they last longer and require less maintenance. Improved design features have ensured that parts can be replaced easily, even by relatively unskilled technicians. Such features include enlarged screw dimensions and guiding sections so that service and repairs can be made easily and cannot be made incorrectly.

A simple example of altered design to improve ease of use is the relocation of the brake release button from the central, relatively inaccessible part of the robot to the outside. This makes it easier for the operator to reach the button when working with the robot. Another improvement is that the robot no longer requires re-lubrication after cleaning, since new low-friction plastic bearings are now used.

A robot for the food industry

The first-generation IRB 340 was used in the food industry and was available with a stainless base-box option. Many other components, however, were made from anodized aluminum, which is washable, but was chosen primarily because it is lightweight. Anodized aluminum cannot withstand scratches or the aggressive detergents used in the food industry. For this reason, the IRB 340 cannot be cleaned using the same methods used for all other food-industry equipment – it requires a more delicate cleaning treatment 4. The new generation IRB 360 has an improved sanitation design, which although heavier, can be more easily cleaned. It has all stainless metal components, including the theta axis, delta plate and arm end caps, as well as a watertight casing (IP 69K), which allows it to be cleaned with hot, high-pressure water at close range. This means that no special time-consuming arrangements need be made to clean the robot. It can be treated just like any other equipment in the plant.

Saving floor space

Floor space is always at a premium in industry and the food industry is no exception. Increasing productivity within a given area is one of the frequent demands made of robots. The standard ABB robot controller is, however, too large for most food and pharmaceutical industry applications, which is why a modified controller was developed several years ago. A smaller footprint was achieved by packing the components more densely and increasing the unit's height. This new controller rapidly gained popularity among picking customers, saving crucial floor space and reducing costs, since the new controller was housed within the customers' existing control cabinets. When developing a new robot, reducing the size of the footprint is a neutral requirement for the development team; however, keeping the number of parts to a minimum is, for cost reasons, a high priority.

The second-generation FlexPicker IRB 360 has a faster cycle-speed, can carry a heavier payload, is more compact and can be cleaned more easily.

The upper arms of the original IRB 340 covered a lot of floor space when pointing straight out. By shortening the upper arms and decreasing the work envelope, the new IRB 360 requires less floor space, even without changing the base box (a floor space reduction up to 30 percent). The width of a FlexPicker cell was decreased from 965 mm to 810 mm and its length reduced from 980 mm to 820 mm. Even greater space savings can be imagined, when the increased cycle speed of the IRB 360 is considered. Higher performance means that seven IRB 360

4 Washing the FlexPicker IRB 340

robots can replace eight IRB 340 robots, providing total floor-space savings of as much as 40 percent.

From picking to packing

The FlexPicker IRB 340 delta robot was first developed for picking and packing small lightweight objects, which are easily relocated, using a simple vacuum cup pickup tool. Once the IRB 340 was released to the market, a large number of different product picking and packing applications were attempted. A popular application today is unloading a flow wrapper and packing products into boxes. This is typically done by grabbing eight to 12 pieces at a time using a large multi-vacuum gripper. Of course such increased payloads, to some extent, slow down the FlexPicker, but worse still they can impact the inertia of the tool. The larger the offset from the center point of the robot tool, the lower the FlexPicker's performance. This can make the robot's operations uneconomical, especially if the operator reconfigures the system incorrectly. If the robot performs outside its design limits, its lifespan and maintenance costs may be affected.

The goal when developing the IRB 360 was to allow an increased payload by increasing the torque on the fourth (theta) axis in the middle, so that the robot would be more versatile, increasing its scope for new applications without reducing the lifespan of the robot. Case packing with a FlexPicker is a very common application, yet by expanding the payload from 2 to 3 kg, the number of packing applications was dramatically increased. The IRB 360 robot can pick up heavier products, handling sausage packs of 2 kg with a 1 kg gripper, as compared to the IRB 340 robot, which can only pick up 1.3 kg sausage packs with a 0.7 kg gripper. This improved performance presents the possibility of doubling production throughput.

5 IRB 340 case-packing coffee at Löfbergs Lila, Sweden

Earlier discussions about payload increases focused on redesigning the arm system. By separating the parallel arm, the new robot could be made stronger, but this would also affect its weight. A further drawback would be an increase in the number of required components, since different arm systems would be needed for different payloads. Again these problems were solved by the new motion controller. The improvements made in robot movement control actually made it possible to handle 3 kg payloads using the same arm system as before with even shorter cycle times. Smoother robot movement and a greater understanding of the robot's limitations have given the IRB 360 a 30 percent performance improvement with a 2 kg payload as compared with the IRB 340 model. Throughput can be increased from 30 to 50 percent in case-packing applications 5.

The sales launch

The sale of the IRB 360 started in April 2008, and its IRB 340 predecessor was completely phased out in October 2008. The smooth transition from IRB 340 to the IRB 360 was possible because the machines are very similar, except that the IRB 360 can outperform the IRB 340 in all aspects. Future sales are predicted to grow thanks to an expanding picking market, despite the recent entry of new competitors to this market. There have already been some significant sales for the high payload variant, outperforming standard robot solutions from competitors. A promising future for the stainless FlexPicker version is also predicted in the meat industry. In fact, in all parts of the world, there is great interest from industries with large picking lines to install reliable robots within a limited amount of floor space. The market is ready and there is a demand for automation with high-speed delta robots. Installations and requests are coming from Turkey, Latvia, Russia, India, Saudi Arabia and other nations with rapidly growing industries. ABB is well positioned to meet this demand with its second-generation FlexPicker and applications experience.

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