ARC BRIEF

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Integral Robotics Raises Agility and Flexibility of Packaging Machinery

Modular Design Techniques Facilitate the Integration of Robotics

ARC Advisory Group

Packaging Machinery Capabilities Critical to New Product Introduction

In today's business climate, execution speed is paramount. Innovative packaging machinery and line configurations that are capable of handling a wider range of product variations are on the horizon. Integral robotics is now becoming the most effective means to add agility and flexibility to a packaging line as this offer rapid reconfiguration and expands the operating range of the individual machine. Specifically, in the Consumer Packaged Goods (CPG), Pharmaceutical, and Home and Health Care industries the agility and the responsiveness of the entire organization from product design to final packaging is critical.

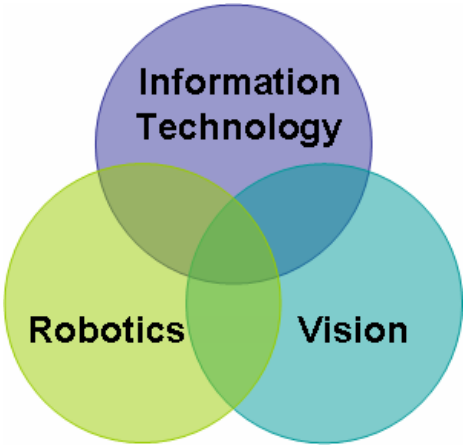
The Rapid Pace of New Product Introductions Demands Agility and Flexibility in Packaging Lines

Formulating a line of finished goods that incorporates innovative features that address specific needs of the end customer is now on a six month lifecycle comparable to the market for consumer electronics. The attributes that are a necessity in each and every element of the enterprise value chain are agility and flexibility, to this end integral robotics are enabling manufacturers to achieve these goals.

In many enterprises, finished goods packaging operations are often the greatest bottleneck to new product introduction. While a large percentage of capital expenditures in the CPG, pharmaceutical, and health care industries are allocated to packaging equipment a majority of this is dedicated to specific product lines and leaves relatively little opportunity to introduce variation in the package design, labeling, and content configuration. The challenge for manufacturers is to define capital equipment capabilities such that final packaging operations are not a critical path to new product introductions.

Packaging Machinery Is an Important Contributor to Supply Chain Execution

The role of individual packaging machines is broadening as businesses adjust to real-time market pull. This requires machinery to be a flexible resource on the factory floor with a greater purpose in maximizing utilization throughout its lifetime. This flexibility simply creates a greater operational range. This has led OEM machine builders toward solutions which combine automation technology from a wide range of domains. Specifically, packaging lines and individual machines continue to witness the convergence of **Robotics, Vision, and Information Technology** with machinery, making it easier to commission, configure, and adapt to the day-to-day variation in production requirements.



Robotics, Vision, and Information Technology Converge with Packaging Machinery

- **Information Technology** is automating the exchange of packaging line production and business data through the standard interfaces or schemas (i.e. Make2Pack, PackML, OPC, Ethernet).
- **Vision** is widely used for inline inspection and now becoming important to machine diagnostics.
- **Robotics** are now being designed as an integral part of the packaging machine.

Convergence of these technologies is clearly improving the overall agility of the packaging line with faster reconfiguration (i.e. changeover) while expanding the flexibility of the line by widening the range of operation.

Robotics an Integral Part of the Overall Packaging Machine

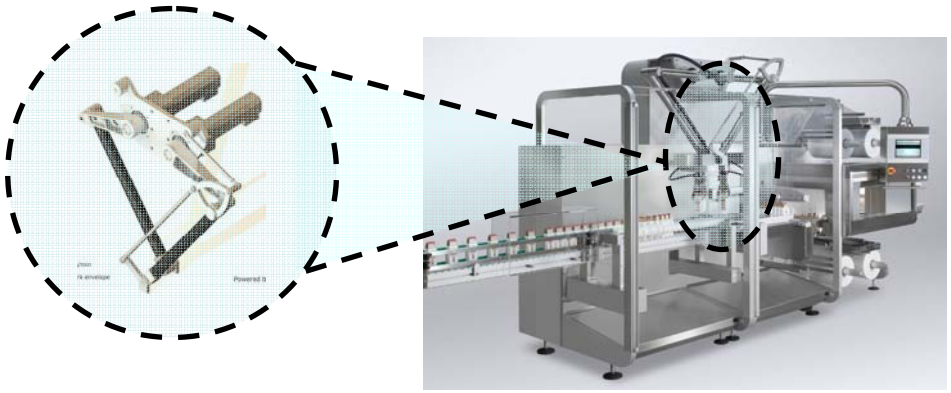
Packaging machine solutions that are adaptable (i.e. flexible) to a wider range of manufactured products are increasingly incorporating robotic capabilities. Historically the mainstay of robotic applications in the packaging sector has been palletizers and case packers; however, there is clearly a movement underway to design the mechanical portion of the

A+F Robotic Case Packer with Graphite Arms Combines Speed and Payload Capacity

packaging machine with an integral robotic manipulator. The implications of this are that the machine variability can be considerably expanded.

The challenge that packaging machine builders face is that robotic motion is generally out of their domain of expertise. The packaging machine builder is generally more comfortable with electronic motion control that performs line shafting, cam shafts, material registration, and phase advance functions, whereas robotics is a specialization in and of itself. The integration of a robotic manipulator requires domain expertise to first define the kinematics of the mechanical configuration and then developing the arm solution. This area of motion control utilizes highly specialized path planning algorithms, blending, and resolving for multiple trajectories to the same point. Depending upon the kinematics of the robot, the trajectory planning may require an iteration solution to determine the correct joint angle for the specific end point of the manipulator on the end of the arm. Other mechanical factors also come into play that can affect the performance of the system which includes friction, backlash, load variations, and centripetal forces all which need to be compensated for using nonlinear algorithms.

These are all challenges that have been solved in the robotics community, however this type of expertise is best purchased as an integrated solution rather than developing the technology in house. Traditionally, a robotic

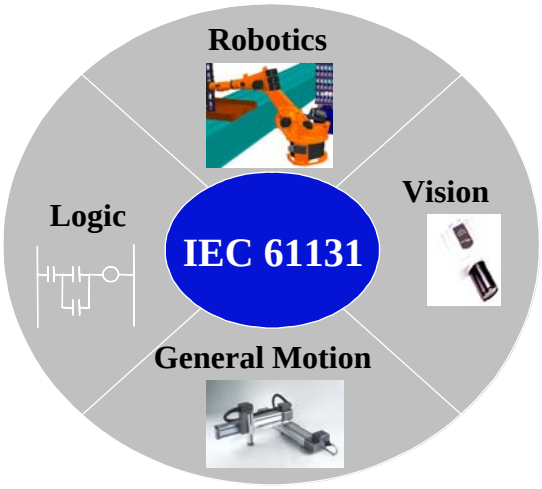


Robotics Capabilities Are Becoming an Integral Part of the Secondary and End of Line Packaging Machines

solution is a self-contained motion controller that incorporates a higher abstraction layer (incorporating teach, multiple coordinated frames, etc.) above and beyond general motion control. However, it is not economical or practical for the machine builder to consider a separate control subsystem simply to integrate a robotic manipulator; the cost of a dedicated robotic control is simply too high. Fortunately, some packaging automation suppliers are recognizing these issues and are adding robotic functionality as an integral part of the machine control system.

Machine Modularity Facilitates Robotic Integration

Machine modularity is allowing machine builders to configure a packaging machine based on functional subsystems such as bottle carousels, labelers, and wrappers. Integration of a robotic manipulator further leverages the concept of modularity by encapsulating this element of the machine as a functional subcomponent that is using a common time base of the overall machine control system. The ability to synchronize material movement is one of the biggest benefits to using a common control system for both the robotics module and the other elements of the packaging machine. It is anticipated that the next generation of automation controllers will extend the use of vision beyond inspection and incorporate vision system capabilities to allow for highly adaptable robotic guidance applications. Software tools that address the motion/vision coordination issue provide an additional dimension of flexibility allowing for less rigid mechanics while also integrating inspection with the machine.



Robotic Application Programming Augmented to Industrial Programming Standards

Integral Robotics Operate Under Standard Industrial Programming Environments

The IEC 61131 industrial programming standard, which has become the norm for Generation 3 machines, allows automation suppliers to extend the language for robotics application. Automation suppliers that support a high degree of software modularity are encapsulating the robotic functionality as a

published library of standardized Function Blocks enabling the application programming for the robotic module to be developed within the same environment as the remainder of the machine control applications. Machine builders seeking to add robotic functionality should identify automation platforms capable of supporting the functionality of a robotic software library. Most importantly adding these capabilities is dependent upon the automation platform's ability to support a high degree of modularity in the IEC 61131-3 software in conjunction with underlying hardware architecture. Overall, the use of IEC 61131-3 Function Block extensions for robotics fundamentally lowers the overall lifecycle cost of the equipment as integration, training, and field support are consistent with existing control strategy.

Robotic Software Library Simplifies Development of Robot Modules

ELAU specializes in automation systems for packaging machinery, and has built a business based on this domain expertise, adherence to international standards, and modularity. Among the first to successfully implement synchronized, multi-axis motion control along with logic in IEC 61131-3, the company was also instrumental in enabling Generation 3 packaging machine design, which by definition incorporates some degree of mechanical as well as software modularity.

This Somic Cartoner Is Essentially a Cluster of Robotic Arms and Servo Collating Belts. Introduced at Interpack These Machines Have Already Been Installed in the U.S. and Canada

What is perhaps most surprising about ELAU, which became a company of Schneider Electric in 2005, is that they have been practicing modular software design since 1998, long before the general control industry. Based on embedded Pentium processor technology, ELAU's PacDrive controllers were designed to permit liberal use of the object oriented IEC Function Block and Sequential Function Chart languages.

Beginning with a template that amplifies the strengths of each of the IEC languages within a given application, ELAU has steadily extended its competitive advantage over the years by

Robotics Can Be Offered as Option Modules or Integral to the Machine, as in this Display Carton Packer from Cavanna

building an extensive software object library of IEC conforming Function Blocks.

Recently, ELAU expanded its libraries to include application-specific robotic, form/fill/seal and capping functionalities. The robotic library turned out to be something of a quiet revolution as a quantity of robotic packaging machines were launched at the 2005 Interpack trade show in Düsseldorf, Germany. These took the forms of both option modules, such as pick-and place and infeed modules, and robotics integral to the machine, with the frame housing a series of belts that present products and package blanks to robot arms that perform the erecting, filling, closing and sealing processes. It was not uncommon for ELAU's mid-range controller to perform all machine logic and motion control functions on a machine in addition to three articulated arms.

The ELAU robotic library supports linear, circular, point-to-point and spline interpolation. Function blocks have been developed to parameterize portal, delta, gantry, SCARA, 2-axis pick -and-place and articulated robot arms. These are practical examples of the benefits of modular software design tools. A number of packaging machinery builders using ELAU's PacDrive™ automation system have taken advantage of the software's modularity to design modular machines with integral robotics. It is the IEC 61131-3 programming languages that are the most viable alter-native for OEMs that are serious about modularity in software deployment. The combination of Sequential Function Charts, Function Blocks, Function Block Diagram and Structured Text along with Ladder Diagram offer the capability ability to develop modules that model the behaviors of the actual subsystem components and separate this from the process implementation that synchronizes and facilitates communication between different elements in the system. In conjunction with programming languages, a

ELAU Demonstrated Its Robotic Software Library with this Delta Robot at the Interpack Show

wide range of data structures and file handling capabilities that facilitate the movement of information between machines and production systems is an extremely important consideration. But, perhaps most compelling is how mechanical design engineers are exploiting modular control software through collaborative Process Design and getting machines to market in a timely and cost effective manner.