rexroth
A Bosch Company

Technical Article

The sophisticated capabilities of today's controls have helped guide the vision for i4.0 technology.

Factory of the Future: Enabling i4.0 with Controls

Today's manufacturing and automation industry segments are constantly leveraging new technologies and processes to help them become more agile, more responsive to fast-changing global markets and more innovative in the products and solutions they offer.

This is the promise that i4.0 technology offers: The Factory of the Future, where everything is smarter and more connected than ever. From the individual machine components with embedded sensors and intelligence, as well as machine-level and plant-level communications architectures and then ultimately cloud-based solutions, sophisticated software and open communications protocols make it possible to collect, transfer and processes data in real time.

The potential in these i4.0 technologies is transformative, providing both production transparency and actionable answers to questions about production bottlenecks, inefficient workflows and equipment in need of preventive maintenance.

Factory of the Future

Now. Next. Beyond.

Key Insights & Considerations

- **When i4.0 controls are integrated with other i4.0 technologies, they should improve a manufacturer's flexibility and speed, enabling more individualized products, efficient and scalable production, and a high variance in production control.**
- **There are several qualities for i4.0 systems that can work alone or together to help bring about the Factory of the Future: decentralized intelligence, rapid connectivity, open standards and systems, real-time data analytics and autonomous behavior.**

Leveraging the power of i4.0 controls

One of the technology elements that is most critical to bringing this Factory of the Future vision to life is the "brains" of today's automation industry: the powerful and versatile controls and controls platforms. In many ways, the sophisticated capabilities of today's controls have helped guide the vision for i4.0 technology. For example, Bosch Rexroth's motion and logic platforms already provide innovative software and firmware functions, easy engineering and open interfaces that enable maximum production performance, flexibility and transparency.

These state-of-the-art systems not only provide a strong foundation for rapidly implementing the Factory of the Future — they also provide a conceptual basis for automation systems designers, machine builders and manufacturing end-users as they seek to fully implement the intelligent capabilities promised by i4.0 technology.

***Bosch Rexroth's motion and logic platforms* already provide innovative software and firmware functions, easy engineering and open interfaces that enable maximum production performance, flexibility and transparency.**

The goal is to deploy technologies that can make a dramatic difference in the way manufacturers operate. When i4.0 controls are integrated with other i4.0 technologies, they should improve a manufacturer's flexibility and speed, enabling more individualized products, efficient and scalable production, and a high variance in production control.

It should also enable small-scale production of single lots alongside mass production, as well as optimized processes and inventory stocks through real-time information transparency and high-production availability.

There are several qualities for i4.0 systems that can work alone or together to help bring about the Factory of the Future: decentralized intelligence, rapid connectivity, open standards and systems, real-time data analytics and autonomous behavior.

Decentralized intelligence

The first is decentralized intelligence, also called distributed intelligence, where intelligent drive and control technologies are designed to network with other devices with decentralized autonomy — putting as much intelligence and control capability as possible within the machine, or even the individual component of the machine, rather than handling all activity and control from a single central processing unit (CPU).

The ability to process data at the machine level and decide what to do with it reflects our belief that you can equip the machine to do something with the process data and improve the process on its own — adjust throughput, utilize energy more efficiently and so forth — rather than depending on the "cloud" to handle all these tasks.

The machines are still connected, still communicating to higher line level, plant-level and enterprise-level networks, but they have the capacity and systems to make event-specific or product-specific adjustments in real-time. Bosch Rexroth has been laying the groundwork for this i4.0 capability for some time: Distributed, drive-based controls is an automation architecture we have been perfecting for several years.

Technology such as drive-integrated servo motors and cabinet-free drive systems, which place drive components and motion logic sequencing at individual axes, reflect this concept in their architecture. Even with hydraulics, the combination of hydraulic actuators with integrated digital control electronics allow control functions to be shifted to local software, where intelligent control algorithms developed specifically for hydraulic requirements are already in place. All the user has to do is define the motion parameters.

Rapid connectivity

Systems that facilitate instant vertical or horizontal connectivity to allow data to flow freely across the enterprise structure need continual investment and improvement. Leveraging all the intelligence and information available on an i4.0 factory floor could overwhelm networks, so this is really a network design challenge:

How can we improve both the physical and software capabilities of our automation systems to make this design process simpler, less-time consuming and more open? We're trying to streamline how the communication paths — both vertically to central production servers and horizontally between production nodes and machines — are created and implemented.

For example, determining what fieldbus capabilities should be utilized; looking at whether the production platform support standards such as OPC UA; determining how much effort will be needed to write drivers to translate machine data for use in the rest of the plant.

These and other communications issues currently take up a substantial amount of time and cost in creating automation solutions, so eliminating barriers between various supplier systems and taking a more open approach to communications and controls platforms is more important than ever in the Factory of the Future era.

***Open Core Engineering** combines high engineering efficiency in automation with the technologies, tools, and solutions of the IT world.*

Open standards and systems

There needs to be a focus on expanding how "open" systems are, both in terms of support for emerging communications and software standards, and in how open individual components are, to make i4.0 a reality. The use of open standards allows the more flexible integration of software-based solutions — with the possibility to migrate new technologies into existing automation structures.

Our award-winning Rexroth Open Core Engineering (OCE) control and engineering platform is a significant step in that direction. OCE bridges the gap between automation and IT software programming and opens up our controller kernel, through the Open Core Interface, to enable the creation of automation applications using common high-level IT languages such as Java and C++.

In the Factory of the Future, the operation of a machine tool or a packaging machine should allow for easy connections with smart devices such as phones or tablets. OCE also offers a powerful tool to help speed the design and commissioning of automation systems with the direct connection of the controller to 3-D dynamic modeling software, like Catia, a software product from Dassault Systemes.

The Rexroth MLC motion controller, for example, can send commands and receive feedback from the model itself, allowing the functionality of the machine to be optimized with motion control in the mechanical design phase. This allows testing and programming of a machine before commissioning, replacing expensive and time-consuming physical prototypes.

Innovative software and firmware functions, easy engineering, and open interfaces ***from IndraMotion MLC guarantee maximum flexibility.***

Real-time data analytics

In i4.0 factories, it will be possible to draw on real-time machine and plant performance data to change the way automation systems and production processes are managed. Instead of capturing and analyzing several months' worth of data on throughput rates, machine downtime or energy consumption, i4.0-enabled platforms will integrate that type of data into routine plant management reporting.

Some have expressed concerns that the new, data-rich environment that i4.0 technology offers will create a mountain of data that will be difficult to manage and utilize in real time – especially when challenged to integrate and effectively analyze information coming from multiple production lines and plants scattered across the globe. In fact, i4.0 controls platforms now offer a powerful resource to address that challenge: embedding an intelligent "edge" or gateway that collects the right data from the factory floor.

These gateways normalize the data streams to provide a coherent and actionable portrait of critical production data in real time. Bosch Rexroth's IoT Gateway makes real-time monitoring of process data, such as temperature, pressure, vibration, power consumption or other parameters, easier to set up without intervening in the automation logic. Data can be centralized at the plant level with local machine state monitoring systems and eventually scale up to use the gateway to connect all production locations through the cloud and utilize cloud-based analytical tools.

With these tools, it is now possible to have much more data-driven solutions to help companies improve a number of critical productivity tools and strategic programs. These include:

***Making data exchange** from existing production machinery simple and instantaneous, IoT Gateway networks plants, production, and logistics properties with the IT world.*

- Predictive maintenance: having better insight about when and how to schedule machine service intervals and equipment upgrades to minimize downtime
- Data analytics: making smarter use of production data and incorporating it into operational and strategic decision-making
- Visualization and notification: feeding digital Kanban boards to visualize production data in real time and network with IT applications for production planning and quality data management; this provides information throughout plants that is the basis for decisions and process improvements
- OEE optimization: using data from across the enterprise to better quantify overall equipment effectiveness (OEE) and compare different production platforms to help guide investments in future equipment
- Business intelligence: enterprise-wide strategic planning to address long-range investments in new production systems, plants, personnel and markets can be guided with solid historical data and better insight from cloud-based analytical tools

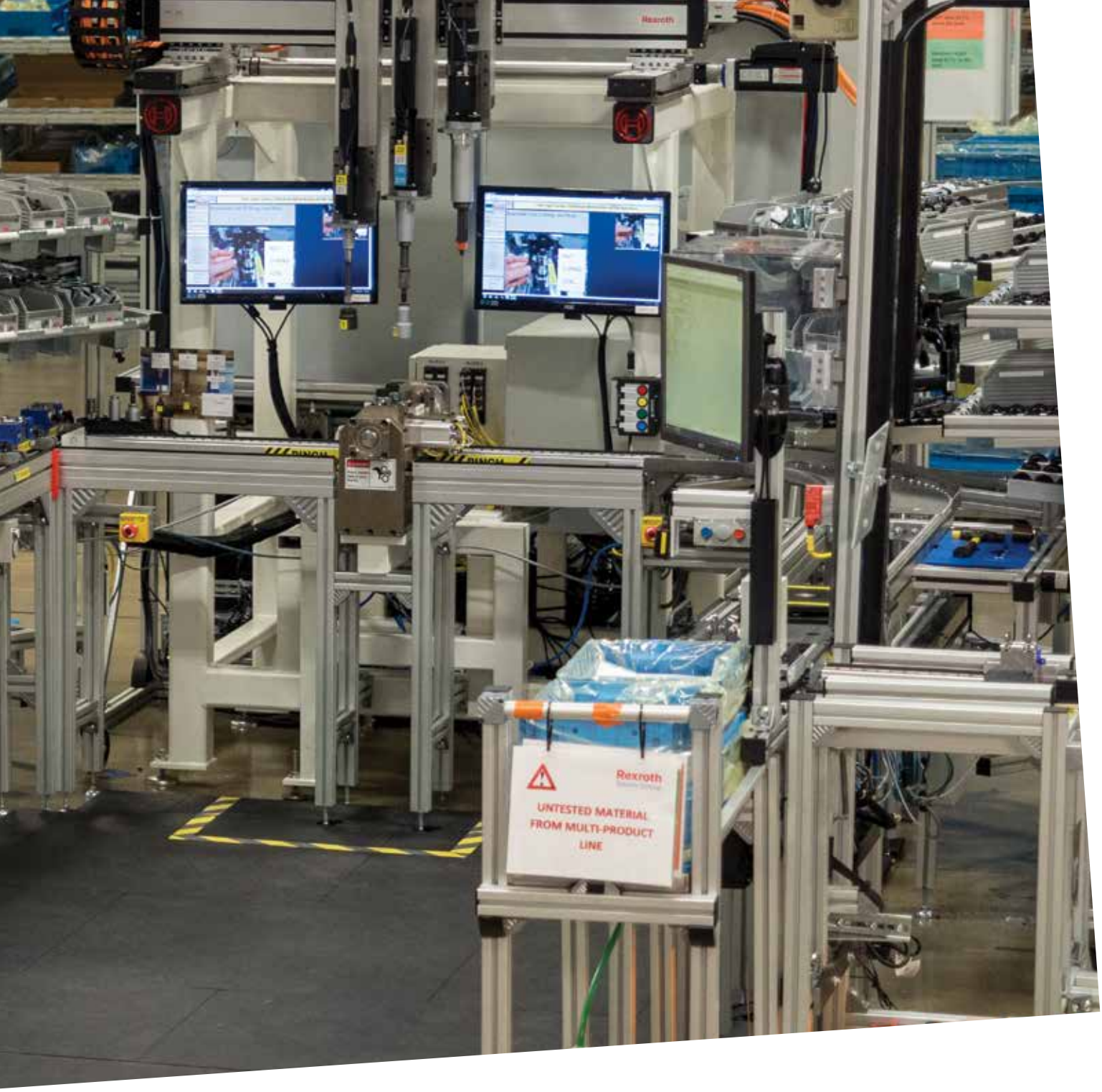
Autonomous behavior

Bosch Rexroth is actively applying i4.0 technology to be smarter, more connected and demand-driven through i4.0 production lines that operate using autonomous behavior. Rexroth's industrial hydraulics plant in Bethlehem, PA, is one of the first Rexroth facilities worldwide to implement a full-scale i4.0 manufacturing line. The new Multi-Product Line (MPL) mixes automated and manual systems with technology that connects operators, machinery and parts to make 34,500 different product variants.

Each worker on the MPL has a name tag with an embedded Radio Frequency Identification Tag (RFID). The individual workstations throughout the MPL are programmed to read the RFID tags and autonomously adapt the workplace to their skills and preferences. This includes ergonomic initiatives, such as height adjustable benches to providing instructions based on experience.

Bosch Rexroth's Multi-Product Line (MPL) in Bethlehem, PA, mixes automated and manual systems with technology that connects operators, machinery and parts to make 34,500 different product variants.

The RFID tag can connect with workstations to send material requests or assembly instructions on behalf of the worker, allowing employees to focus on creating high-quality products. Using RFID tags, Rexroth ensures that each employee can work in a space designed specifically for their needs, increasing worker productivity and comfort.



All products made on the MPL have a unique identification tag. As the products move down the line, their RFID tags are closely monitored by the production control system to trigger replenishment of components when necessary. Additionally, product carts are identified by RFID tags and alert Automatic Guided Vehicles (AGV) to automatically pick up materials for the next production cycle.

Scalable Pathways to the Factory of the Future

It's important to appreciate that the Factory of the Future is already being built — and the power and sophistication of today's i4.0-enabled controls platforms play a critical role. They provide an intelligent foundation for a smart, step-by-step approach to implementing the benefits and advantages that the Factory of the Future offers.

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