IoT To The Rescue For Biotech & Pharma Manufacturing

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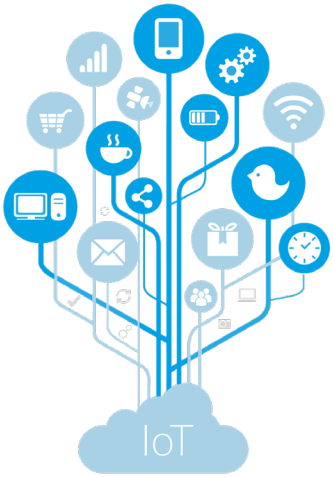
The Internet of Things (IoT) could not be timelier for biotech/pharma. With fierce cost pressures, the push for value-based outcomes, and the need for flexible manufacturing solutions, the IoT is the much-needed shot in the arm to bring about transformational change.



Sensors, actuators, and devices ("things") embedded in production equipment and networked through computer systems can generate an enormous amount of data. The data can be mined for insights and opportunities to drive production efficiency, automate monitoring and controlling functions, and enable flexible manufacturing systems.

Intelligent apps and software are central components of an IoT system. They allow the "things" in the system to communicate with one another and to initiate or execute processes with less operator intervention. In this new world, machines predict failure and trigger maintenance processes autonomously. Software modules, analysis, and combinational logic make functional integration possible. Software automatically adjusts machinery if it detects a measurement has deviated from acceptable ranges.

Expect changes in manufacturing product design

While connected "things" can measure more than ever before, without automation it is extremely cumbersome to extract value from the data. To convert the data into value requires changes in the design of manufacturing products and retrofitting of existing manufacturing equipment. To meet future needs, designs must include the following:

- intelligent, self-regulating, and self-controlling components for plug-and-produce
- flexibility to enable economical manufacturing of different types of batches and sizes, fast balancing of the workload in a production network, and prompt adjustment to the orders in hand
- comprehensive condition monitoring to avoid downtime and optimize maintenance procedures and mobile maintenance.

Four IoT technologies for biotech & pharma today

While IoT adoption has been led by consumer applications, 70 percent of its projected economic value will come from B2B applications, according to McKinsey Global Institute. Until recently, the IoT was talked about in the future tense for the biotech and pharma industries. But, IoT applications are here now. Let's consider four ways biotech and pharma can benefit from the IoT today.

I. DIGITIZATION OF PNEUMATICS

Equipment designed today has some limitations as process requirements change. Limitations of solenoid valves are a good example. In a traditional sense, solenoid valves are used to pilot downstream processes such as sanitary diaphragm valves or a quarter-turn actuator on a CIP system. The function of a pneumatic solenoid valve is determined when the automation concept is designed and there is no flexibility to adapt the function as equipment needs change. Typically, a separate valve is required for each functional need. If process requirements change, the valve must be replaced. For instance, if the simple function of a process valve needs to change from single acting to double acting, the solenoid valve must be replaced to operate accordingly.

Festo's recent introduction of the Motion Terminal revolutionizes pneumatic valve functionality. It does this by combining mechanics, electronics, and software in the form of a cyber-physical system.

The Motion Terminal is the first valve to be controlled by apps. Pneumatic functions are no longer automatically connected to the mechanical hardware. Nor is a valve limited by its physical design. With installed corresponding Motion apps, functions can be changed with a simple command or at the press of a button, whether for a simple change in the directional control valve functions, energy saving mode, proportional characteristics, or a format change.

Four Motion Terminal Apps - The Motion Terminal is designed with the flexibility to add more apps in the future as needs are identified. Four existing apps demonstrate how the terminal can add value to a biotech or pharma manufacturing operation today.

I/P Proportional Control

The Motion Terminal has the ability to switch a standard directional solenoid valve into a proportional pressure regulator. Many applications today require proportional pressure such as air blankets for bioreactors. Currently, inert gas is supplied to a reactor using a separate valve and sensor setup. With the Motion Terminal, a standard pilot valve can easily be switched to dual independent proportional pressure regulators. Valves of different function can be installed on the same terminal. This eliminates the need for and the costs of adding a separate inert gas control system.

Many other niche applications in a pharmaceutical facility requiring proportional pressure could be controlled by the pilot valve terminal. Another benefit is the significant reduction in the number of components at the reactor and the complexity of the system. Learn more about proportional valves for closed-loop control of inert gases in process automation.

Flexible Use Of Valves

The Motion Terminal adds significant flexibility for pneumatic valve functionality. Traditionally, a pneumatic valve has one function. Each separate function requires an additional valve. The Motion Terminal changes that.

With the Motion Terminal, one valve can perform all functions, creating flexibility that could only be imagined in the past. For example, a valve with five ports can also function as a valve with three ports. Or, a valve that opens and closes and turns on and off can also be used to fine-tune the pressure or the flow rate. Having so much capability in the same design is revolutionary.

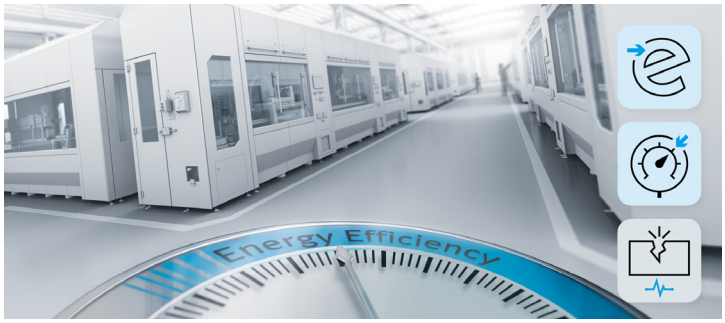
With current systems, as many as 50 separate products or positions may have been required to cover a multitude of valve functions. Now, with the Motion Terminal, a single valve type can function for an extremely wide range of pneumatic movements and functions — without modification, added parts, or installation.

This feature offers tremendous opportunity for ***flexible manufacturing***. Standard OEM equipment for a contract manufacturer, for example, may be designed to the processes of a specific drug today and then a different way tomorrow. Flexibility at the pneumatic stage provides the ability to change from a 3/2 or a 5/2 valve to a proportional valve or to a discrete (on/off) valve.

Using fewer components offers these additional benefits:

- Reduces the component validation burden
- Simplifies preventative maintenance
- Reduces the number of supplier interfaces
- Speeds time to market

Leakage Detection



Understanding how much compressed air is being utilized for each leg of a pneumatic circuit can be a daunting or expensive challenge. But such knowledge is critical for early detection of a downstream issue that could lead to process failure. Traditionally, such an analysis at the component level would require sensors, additional I/O, and programming to automate the analysis.

The Motion Terminal is able to precisely measure the pressure flowing through the valve and calculate air consumption. The measurements can be compared to predetermined settings. This analysis happens locally at the valve terminal, eliminating the need for additional sensors or detailed comparison code at the controller or DCS level. When the valve is consuming more air than expected for a process, a message will be sent to the controller.

Preset Of Travel Time

For some critical life science applications, it is important to control the opening and closing time of an actuator. This could be a linear actuator or a quarter turn actuator for a ball or butterfly valve. It is possible now to set a desired travel time at the pilot valve via an app or supervisory controller. Using sensors on the actuator, the valve on the Motion Terminal will adapt the air flow to consistently meet this desired time. Today, this is achieved with simple mechanical flow controls that restrict flow, but this solution is not dynamic and cycle times will change over time. A change in ball valve torque, the wearing of an actuator seal, a small leak at a fitting, or degradation of line pressure will not be compensated for automatically without manual adjustment. It is now possible to automate this with minimal effort or cost. If the desired cycle time is no longer achievable, a message will be sent to the supervisory controller.

II. PREVENTATIVE MAINTENANCE

The ability to analyze streaming data to assess conditions, recognize warning signs, and service equipment prior to failures prevents costly equipment downtime. Strategically scheduling preventative maintenance for when equipment is not in use further reduces downtime.

Automated valve cycle counts

Cycle counts can be used to alert the operator to replace a valve for preventative maintenance at a predetermined count. This information can be pulled at any time via the controller and can be programmed to provide an alert at defined intervals.

Compressed air usage

Compressed air usage is an excellent indicator for predicting maintenance needs. Increases in compressed air consumption can be an early indication of:

- Leaking seals at a quarter-turn actuator or pneumatic linear actuator
- Early-stage cracks in piping or welds
- Failing flexible tubing or fittings
- Solenoid valves not closing properly
- Failing pneumatic pumps
- Problems with a nitrogen air blanket
- Faulty vessel seals

Investigating the source of this consumption increase early on and correcting the problem will improve the performance and uptime of all automated plant equipment.

Compressed air usage monitoring can be automated within a Motion Terminal app called “Leakage Detection” or by installing a flow sensor before a traditional solenoid valve terminal. Flow sensing can detect problems such as a leaking tube, a split in a hose, a ruptured diaphragm, or worn O-rings. Learn more about flow sensing as an indicator for preventive maintenance.

III. DIAGNOSTICS

For any valve terminal, the ability to determine the health of the system can prevent costly downtime. The data and insights from an IoT-enabled manufacturing system can provide real-time intelligence about the current component and system state.

The IoT enables data to be provided in real time. It can then be monitored locally or remotely. Failure events can often be preempted with the use of data. But if a failure does occur, human reaction time can be much faster because of the real-time data. Production can be stopped more quickly, resulting in less wasted product.

Undervoltage per module	Short circuit selectable	Wire break selectable	Upper/lower limit value	Error memory	Condition monitoring	Undervoltage per valve manifold	Monitoring of space required control	Pressure-monitoring
– Electronics -25%. – Load -10 %. – Emergency-stop≤10V.	– For each channel. – For each module. – For each valve.	– For each channel. – For each module. – For each valve.	– For each analogue channel. – Voltage. – Current. – Temperature.	– Last 40 messages. – With a time stamp. – Recognising of sporadic errors.	– Setpoint specification for each valve. – Monitoring of downstream mechanics/ processes. – Preventive diagnosis/ maintenance.	– Additional supply for valves monitored separately.	– Pull current. – Coil clamped. – Manual override not reset.	– Threshold value. – Comparator. – 16-bit numeric.

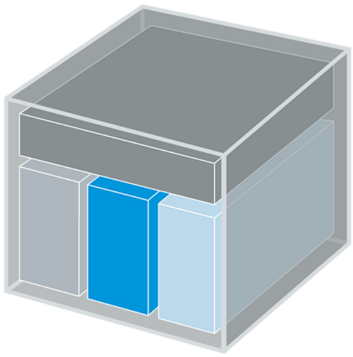
Without the new technology, a failure or outage may be discovered from a downstream sensor alerting you to no air flow. The time-consuming troubleshooting then begins. Is it the diaphragm valve? Is it a broken hose? Is it a faulty pneumatic valve? New digital technology, by contrast, informs the customer of exactly where the problem is. Providing the specific point of failure (e.g., sensor wire 7 is broken) eliminates troubleshooting time and reduces downtime.

Festo’s I/O and valve terminals have a bus embedded into the subbase that is able to provide point diagnostics triggering an alert on an HMI or supervisory controller. Learn more about the use and installation of diagnostic solutions and plant health intelligence.

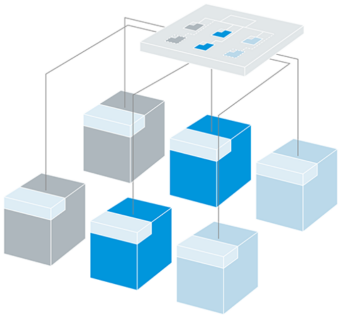
IV. MODULAR AUTOMATION

The biotech and pharma markets are experiencing increasing demand for short product development times and customized products. To meet these needs requires a shift in how process plants are designed and engineered.

Flexible manufacturing systems can be achieved by dividing a complete plant into functional units — a concept called **modularization**. Production modules can be combined to produce specific process plants which can then be extended by adding modules. This concept enables immediate adaptation to changing market and production requirements. Capacity is increased or decreased by “numbering” up or down (with smaller, fully functional units), instead of “scaling” up, a model



Central control system
CIP module
Pump module
Filtration module



HMI - Human-Machine Interface
Decentralised module control
Autonomous CIP module
Autonomous pump module
Autonomous filtration module

that worked when production volume for a single product was much greater. This concept of modularity is how smaller batches and multiple types of products can be efficiently produced in the same plant.

Each module has its own intelligence composed of parts such as the Motion Terminal described above. Learn more information about flexible manufacturing plants based on the Lego principle and modular automation with valve terminals.

IoT: A Look To The Future

Biotech and pharma manufacturers that adopt IoT technology will reap the benefits of production efficiency, product reproducibility, and manufacturing flexibility. Festo is proud to be on the leading edge of redesigning automation technology to meet the needs of this rapidly changing industry. Plant engineers are now able to design plants and equipment in drastically different ways than just a decade ago. The applications described here, while promising, are a small glimpse of what is to come.

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