The impact of the Internet of Things on industrial ovens and furnaces

by Thomas Rücker, Peter Sherwin

The industrial furnace of tomorrow is a smarter machine – safer, better connected, more flexible, and more efficient – to quickly respond to new demands. Two trends that are creating a lot of buzz today are about to unleash a profound change through-out global industry: Industrie 4.0, the German based approach for smart manufacturing, and the Industrial Internet of Things (IIoT) with a focus on connected devices and analytics. In this report, however, the focus is on how industrial ovens and furnaces will be impacted.

There are some obvious similarities and differences between IIoT and smart manufacturing (Industrie 4.0), as well as areas of convergence. Smart manufacturing or Industrie 4.0 initiatives are focused on manufacturing flexibility, increasing automation levels, and digitization. This is not so much the next industrial revolution but an evolution. In the long run this will reshape complete factories and the way they operate. Such evolution requires embracing a multitude of technologies and ideas which will have a massive impact on end users and OEMs. This will take some time and IIoT, with all its connected devices, will act as a key enabler.

The IIoT vision of the world is one where smart connected assets (the things) with varying levels of intelligent functionality, ranging from simple sensing and actuating, to control, optimisation and full autonomous operation, operate as part of a larger system. These systems are based on open and standard internet and cloud technologies that enable secure access to devices and information in order to leverage big data and analytics and mobility technologies to drive greater business value. Introducing IIoT solutions using a “wrap & re-use” approach, rather than a “rip & replace” approach will enable greater business control. In addition, this measured approach will drive the evolution towards a smart manufacturing enterprise that is more efficient, safer, and sustainable.

SMART MANUFACTURING

While the long term impact of IIoT is at times difficult to predict, three distinct operational environments will set the stage for the smart manufacturing enterprise to emerge [1].

- Smart Enterprise Control – IIoT technologies will enable tight integration of smart connected machines and smart connected manufacturing assets with the wider enterprise. This will facilitate more flexible and efficient, and hence profitable, manufacturing. Smart enterprise control can be viewed as a mid-to-long-term trend. It is complex to implement and will require the creation of new standards to enable the convergence of IT and OT systems.

- Asset Performance Management – Deployment of cost effective wireless sensors, easy cloud connectivity (including WAN) and data analytics, will improve asset performance. These tools allow data to be easily gathered from the field and converted into actionable information in real time. This will result in better business decisions and forward-looking decision making processes.

- Augmented Operators – Future employees will use mobile devices, data analytics, augmented reality and transparent connectivity to increase productivity. As fewer skilled workers are left behind to man core operations due to a rapid increase in babyboomer retirement, younger replacement plant workers will need information at their fingertips. That information will be delivered in a real-time format that is familiar to them. Thus the plant evolves to be more user-centric and less machine-centric.
SMART MACHINES (INDUSTRIAL OVENS & FURNACES)

Industrial ovens & furnaces will evolve their level of intelligence in order to accommodate more predictive planning and more flexible business needs. The term “smart machine” implies a machine that is better connected, more flexible, more efficient and safe. It can quickly respond to new demands. Based upon a collection of smart, connected products, it maximizes efficiency through intuitive collaboration with its users. A smart machine (Fig. 1) is also capable of participating in predictive maintenance practices while minimizing its own environmental footprint and total cost of ownership [2].

EFFICIENCY

Self-awareness

With the use of sensors and the intrinsic knowledge regarding its own capabilities and features, a smart machine will be able to monitor its own key components as well as environmental conditions. Embedded intelligence will correlate upstream and downstream behaviour and adapt its own parameters within given business rules. By providing relevant information to both operators, connected data consumers at the OEM, and the end user, the smart machine enables manufacturing lines to produce in a more reliable, flexible and efficient manner. Such optimization can be implemented with respect to energy, time, OEE, load shedding, quality or other parameters via upstream systems that provide set points based on analytics.

Specific Heat Treatment applications:

- The addition of environmental sensors in control panels to monitor control instrument terminal temperatures; it has been demonstrated that controlling this temperature (via cabinet fans or air conditioning units) can significantly improve calibration drift performance.
- Control systems are becoming more sophisticated by enabling the use of process material specifications (example: steel alloy composition) to refine operating cycle parameters. Embedding auto calibration technology into 3GASIR sensors in online carburising applications significantly improve the overall process accuracy (Fig. 2).
- The discrete monitoring of quality (defect information), maintenance (downtime periods) and production activities (turnaround times) can now be improved by utilising IIoT solutions to coordinate and combine these separate activities into a single Overall Equipment Effectiveness O.E.E KPI enabling a better understanding of the overall performance of the plant.
Silicon controlled rectifier (SCR) power controllers (or thyristors) were developed to provide a precise method of electrical switching in the control of power circuits in heating applications. They were also designed to overcome the limitations and lifetime issues of mechanical contactors. The SCR technology is now being used to take an isolated controller and provide a system approach to managed power demand. A number of SCR devices will fire randomly at what could be many times per second. If the units fire at the same time, then the load demand increases. By using power sequencing across an Ethernet backbone to enable automated load balancing and load shedding techniques it is possible to order the firing pattern and reduce the ultimate peak load demand. These smart connected devices can be used for single or multi-zoned equipment and can also be leveraged across multi-equipment cells.

This level of machine monitoring (Fig. 3) also enables preventative maintenance supported by the Supplier/OEM, helping to avoid component failure and associated downtime or damage to the machine or components. It also allows for maintenance to be scheduled, in order to minimize the impact on production while increasing business opportunities for value added services.

Data Management
Smart machines must have the appropriate level of intelligence to assess data quickly and in a decentralized fashion. Routing all data to a central control for analysis will quickly lead to delays as it is a non-scalable structure. Sensors, components and machinery with the intelligence to only share data that falls outside of set parameters will lead to better overall data management. Improving the level of data shared with the broader network/community will accelerate decision making and reduce backlogs (where critical information could be delayed or missed altogether).

It is common to have the control instrumentation for a furnace as close to the equipment as practically possible to enable quick precise process control and data capture at source to avoid potential data loss through remote-only solutions. This data is then is shared with central systems using a robust ‘store-and-forward’ system to protect the base-data. The regulated aspects of heat treatment, driven by the aerospace industry (NADCAP/AMS2750E) and automotive industries (TS16949/CQI9 Issue3) prescribe the requirements for tamper-resistant data capture and long-term storage.

An extension of these features set in data management systems now provides security management and full audit trail functionality. These smart data management systems and digital chart recorders have evolved into mini-productivity stations enabling key information for thermocouple use, calibration tests and machine maintenance to be scheduled directly on the device (Fig. 4).

The final storage of data is also an important consideration. To date, hardware has largely been used to store production data, but this method can be very time consuming and expensive to manage. The secure cloud is increasingly becoming a viable option to help better manage data in a more cost-effective manner for long term storage (for example long term retention periods of 30 years or more).

SAFETY AND SECURITY
With security built into their fundamental designs, smart machines will improve the safety of operators and minimize the security risk of increased networking. Improvements in machine performance and lifetime cost reductions cannot be offset by reducing the safety or security of the machine or production line.

The ability to utilize a mix of safety components and controllers, will allow machine builders to fit the solution to specific end user application requirements, helping to improve overall performance and productivity.

Today, data security is the leading inhibitor of end user adoption of new networking technologies and work processes. The perceived risk of networking components and machinery in order to achieve production benefits is high. Particularly with IIoT and increasing levels of connectivity, security needs to be considered at numerous levels. Security
provision needs to be multi-layer, incorporating hardware, software and services. Machine builders (and automation component vendors) need to assure that end users are aware of security vulnerabilities, and can manage network infrastructure to minimize the risk of a breach. To help with education of end users as to the benefits of smart machines, and how security can be maintained with increased I/P connectivity, use cases and success stories need to be highlighted.

**FLEXIBILITY**

**Plug & Work**

Any new smart machines will need to be compatible with the existing installations or machinery from multiple OEMs; end users want devices that can be installed within a short timeframe. Integration into the rest of the system must be easy.

- Industry hardened scalable data hubs for heat treatment are a method of being able to take direct input from wired sensors and digital signals from other local devices to capture data near to source and provide a method for a secure link to both plant based business systems for internal analysis as well as to storage in remote secure data centers.

**Modularity**

The lifecycle of today’s machines does not allow monolithic or single purpose design anymore. The fast development driven by time-to-market constraints force OEMs to shift towards mechatronic design and modularity. This trend also continues in the software and application part of modern machines. Smart machines will benefit from templates of proven design form simple software functions up to fully functional modules describing mechanics, electrical, motion and interfaces, features and behaviour.

**Reusable design**

Machine builders embrace concepts that are proven, reliable and validated. Modularity is one enabler where the paradigm to reuse software and hardware in a different context requires a new level of thinking. The concept of Furnace TVDA solutions (Total Validated Documented Architectures) will provide building blocks for furnace control panel design and will become common use in the future. The concept of clear and strict interfaces with well-defined behaviour that can be tested comes from the IT world and finds its space in automation with some adaptation. This becomes another key smart machine differentiator.

**CONNECTIVITY**

**Connectivity**

Smart machines will connect directly to the broader (Ethernet-based) network. This enables data sharing and production planning, which goes far beyond the capabilities of traditional standalone machinery and automation. Smart machines will bridge the information technology (IT) and operations technology (OT) gap, making available production data that can be used in numerous management settings (e.g., stock control, operator scheduling, maintenance, energy management, and product replacement). A basic requirement for this: standards to put values and parameters in a meaningful context and a common language.

Heat treatment quality standards helped drive the development of direct communication links between the control device and the recording instrument to eliminate errors created by conventional retransmission methods. Ethernet-based Modbus TCP was used for device-to-device communications to accurately transfer the control data to the process record. This instrument-to-instrument communication has been a feature of IIoT development over the past ten years.

It is recognized that to increase the value attributed to automation projects, the links between the equipment, operator and supply and delivery chain need to be further developed. Workflow type applications are leading the charge in this area. Below are some examples:

- Production applications embedding regulatory IP (example CQI9 Process Tables) into software workflow solutions provide a link between machines and all the key decision makers in real-time. This ensures regulatory requirements are constantly being achieved and that auto-alerts are raised for any standards breach on a batch-by-batch basis.

- Digital compliance and calibration solutions enable easy planning, scheduling and deployment of instrument calibration tests to minimize Furnace downtime. The digital applications improve process efficiency and reduce the risk of human error when completing status checks by providing an easy to follow sequence of calibration steps. Calibration & compliance status is instantly available online so to enable readiness for any audit. Digital storage also eliminates all the associated issues with storage of paper records – find records when needed via instant access to certificates at the furnace instrument through scanning the QR code with a smartphone.

- The calibration data (non-process data) can also be shared in real-time with the OEM/Supplier through secure data centers to assess the health of the equipment control system and using drift performance and other data can assess service requirements.

**Digital Mobility**

Machine operators and factory floor engineers are embracing in ever greater numbers the concept of using mobile
devices at work. Personnel no longer need to be in close proximity to a machine in order to monitor or manage performance. These devices provide operators with the flexibility to move around while still accessing machinery data. Machine engineers can also diagnose problems and offer guidance remotely, which also speeds up implementation of a solution. This reduces downtime and losses from component failure.

- Instruments with webserver ability have been in general use in the heat treatment industry for the last ten years, and the ability to view multiple machines either on premise or remote (generally through a VPN connection) has been a standard on the more sophisticated data management systems. Technology developments have now enabled this type of feature to be available in entry-level instrumentation.

- Augmented reality applications will provide users the ability to have a virtual view of their production environment. An example application is a virtual view of the inside of a furnace control cabinet and overlaying the status of devices (environmental condition, alarm status etc.). This can lead to quicker diagnosis of any maintenance issues and in certain cases removes the need to halt production to access the inside of the control panel.

WORKER COMPETENCY REQUIREMENTS

The skill-sets required to design and operate an IIoT-based system are somewhat different from those needed to run a classical automation system. A significant amount of re-training will be required for existing operators and maintenance staff to manage such systems. The good news is that the IIoT systems will use technologies that are familiar in everyday life, and the new generation of young operators will have no problems adapting to this new approach. The main challenge for automation suppliers will be to design and supply diagnostics/debug tools that can rapidly identify the root cause of problems. This will ensure that a malfunctioning or downed system can be restored quickly.

CONCLUSION

Traditional heat treatment ovens and furnaces were historically characterized by high-cost and limited communication technology. New smart machines are using established communication protocols, IIoT devices, and the cloud, to enable life cycle cost reductions, machine performance improvements, and new ways to interact with all workers. The new IIoT technologies and practices are evolving over time. Before a large-scale transition to smart machinery occurs, affected workers will require education and executives will require a clear demonstration of payback if they are to invest in improvements. The new technologies will need to prove themselves over time in an industrial environment, and inhibitors such as security concerns will need to be overcome.

LITERATURE


AUTHORS

Thomas Rücker
Eurotherm by Schneider Electric
Limburg, Germany
Tel.: +49 (0)6431 / 298-233
thomas.ruecker@schneider-electric.com

Peter Sherwin
Eurotherm by Schneider Electric
Aurora, United States
peter.sherwin@schneider-electric.com
Knowledge for practitioners

Heating | Hardening | Annealing | Brazing | Welding

This book provides selected physical and technical basics of induction heating and informs practical oriented along numerous application examples about the construction, the set-up and design of up-to-date equipment and processes of induction heating used for forming, heat treatment, joining and cutting as well as for various special applications. Furthermore a separate chapter is devoted to the detailed description of power supply technologies of induction heating processes. The book is of particular assistance to users, manufacturers and designers of induction heating equipment, but also to engineers and students of pertinent specialization.

Editors: Bernard Nacke, Egbert Baake
1st edition 2016, approx. 250 pages, hardcover,
ISBN: 978-3-8027-2391-9
Price: € 120.-

PDF ebook
ISBN: 978-3-8027-3048-1
Price: € 120.-

Available from September 2016

Order now by fax: +49 201 / 82002-34 or send in a letter

Yes, I place a firm pre-order for the technical book. Please send ___ copies of Induction Heating
at the price of € 120.- (plus postage and packing)

Company/institution:

First name and surname of recipient:

Street/P.O. Box, No.:

Country, Postcode, Town:

Phone                      Fax

E-mail

Line of business

Date, signature

Please note: According to German law this request may be withdrawn within 14 days after order date in writing to Vulkan Verlag GmbH, Versandbuchhandlung, Friedrich-Ebert-Str.55, 45127 Essen, Germany. In order to accomplish your request and for communication purposes your personal data are being recorded and stored. It is approved that this data may also be used in commercial ways by mail, by phone, by fax, by email, none. This approval may be withdrawn at any time.