Ipsen delivers

The Power of PdMetrics™: Optimizing Operations with Predictive Maintenance

Aymeric Goldsteinas

Ipsen

Hard Work Wins

The Power of PdMetrics™: Optimizing Operations with Predictive Maintenance

Aymeric Goldsteinas
Ipsen, Cherry Valley, Illinois, United States

Abstract

One of the key objectives of heat treatment is ensuring consistent, high-quality results. This means keeping furnaces in excellent condition in spite of their frequent exposure to extreme conditions. However, with the numerous maintenance methods (e.g., corrective and preventative maintenance) applied, there are still occasions where the furnace breaks down, resulting in lost production and unplanned downtime.

Providing a fresh look at predictive maintenance and the Internet of Things (IoT), this paper discusses the ways in which predictive maintenance is emerging in the thermal processing industry as a powerful tool for analyzing performance and efficiency. One such tool is Ipsen's PdMetrics™ software platform for predictive maintenance, which features sophisticated monitoring/diagnostics that integrate with critical furnace systems to provide you with insights never before seen in the industry (Fig 1). This paper will also take an in-depth, analytical look at how predictive maintenance allows you to:

- Anticipate future furnace problems
- Reduce unplanned downtime
- Achieve better furnace performance through proactive maintenance
- View your furnaces in real-time for faster, better decision making
- View the health of all furnaces at all of your facilities with furnace fleet analytics
- Analyze data surrounding failures to determine the root cause

Figure 1: PdMetrics™ software platform integrated on a TITAN® 2.0 vacuum furnace.

Introduction

What if your furnace could …

… tell you that it isn't operating correctly?
… tell you when a vacuum pump rebuild is going to be necessary?
… tell you that you are at risk of experiencing discoloration in the next cycle?
… tell you that you will not pass the leak back test in three weeks?

What if your furnace could warn you about a heating element failure, order the part and schedule the service needed to install it?

These *what ifs* are the motivating drivers pushing predictive maintenance technology to the forefront of product development and maintenance strategies for industries across the globe. And in the near future, customers are going to expect all heat treatment furnaces to be capable of leveraging the Internet of Things to perform such analysis (Fig 2).

Figure 2: The progression of equipment as it becomes increasingly integrated with the Internet of Things. "Service" represents the capabilities of a traditional heat treatment furnace, while "Analyze" represents a heat treatment furnace integrated with predictive maintenance (courtesy of PTC).

Currently in the thermal processing industry, when a heat treatment furnace breaks the result is clear: production comes to a grinding halt and the personnel needed to resolve the issue might not be immediately available. As a result, companies are faced with unplanned downtime until the problem is resolved, potential overtime wages for the necessary personnel and the cost of rushing critical part shipments. In an effort to combat this issue, the ultimate goal of predictive maintenance and Ipsen's PdMetrics™ software platform for predictive maintenance is to carry out maintenance at a scheduled time when the maintenance activity is most cost-effective and before the equipment's performance decreases below the set threshold.

Watch the video on predictive maintenance and discover insights never before seen in the industry: http://bit.ly/IH-WP-1

As today's equipment continues to evolve in the attempt to optimize operations and reduce unplanned downtime, predictive maintenance will also continue to become more widely utilized. By examining the emergence of predictive maintenance as a tool for analyzing future performance and maintenance needs, as well as how Ipsen's PdMetrics software platform is revolutionizing the thermal processing industry, one can better understand how companies are to successfully increase production and improve operations while also reducing costs and unplanned downtime.

Powerful but Simple Diagnostics

The PdMetrics™ software platform securely connects to a network of integrated sensors in your furnace to gather data, analyze it and provide real-time diagnostics that improve the health and integrity of your equipment.

After the data is analyzed in Ipsen's secure Diagnostic Support Center – where they look for anomalies and trends that may indicate the need for further actions – they contact you directly with suggested next steps when needed. If the Platinum Protection Plan was selected, Ipsen will also send a qualified technician and any needed parts to help resolve the issue. The PdMetrics platform also provides several advantages, including the ability to:

- Leverage Ipsen's experience through automated analysis performed by the PdMetrics algorithms
- View furnaces in real-time for faster, better decision making – from monitoring dashboards at the furnace, office PC, smartphone or tablet to sending urgent alerts by text or email
- Achieve smart factory integration with furnace fleet analytics, allowing you to see the health of all furnaces at all of your facilities

PdMetrics is available as a retrofit or with the purchase of a new furnace. It also functions as a furnace add-on that is not integrated with the PLC, meaning it can be quickly retrofitted to the global installed base, including non-Ipsen brand furnaces.

Development of PdMetrics Software Platform

The PdMetrics software platform was developed by Ipsen as a way for companies to create value from the wealth of data that is available from their equipment and processes ran in the furnace, thus being able to efficiently, and cost-effectively, reduce unnecessary downtime. It provides furnace users with four primary features: the ability to achieve maximum equipment performance, a Diagnostic Helper with access to vital tools and resources, an intelligent maintenance routine and continuous optimization of furnace usage. Each feature interacts and builds off the other to create an integrated user experience (Fig. 3).

Figure 3: The PdMetrics software platform dashboard, where users can monitor the health and integrity of the hot zone, pumping system, cooling system and vacuum integrity.

For example, rather than replacing your hot zone components or checking for discoloration based on how much time has gone by, the PdMetrics algorithms running in the background analyze a variety of data points to let you know at the earliest possible time that a negative deviation has started. However, the PdMetrics software platform doesn't stop there. It also:

- Analyzes pumping performance, trending vacuum levels and compares them to ambient humidity conditions and leak-up rate
- Tracks the cooling motor vibration to provide early warning of motor bearing failure
- Monitors and compares several hot zone data points, looking for trends that may produce failures or reduced uniformity
- Checks for trend changes of numerous real-time data points that are early indicators of component or furnace problems
- Pushes algorithm improvements automatically to the entire PdMetrics installed base
- Checks argon or nitrogen quench gas purity before every backfill or partial pressure cycle (this is an optional feature)

Possessing the ability to monitor key furnace parameters and critical data is becoming an essential need as companies focus on reducing machine failures and, thus, maintenance costs. In fact, industry studies have shown that "the failure of a machine critical to an operational process can have a major impact on the revenue that can be generated by a firm […] Accurate, timely predictions can save millions of dollars in maintenance costs" [9].

In the end, implementing a predictive maintenance software platform provides solutions for all personnel levels – from the furnace operator, who can easily monitor the furnace's health and ongoing status, to management, who has a complete overview of the entire operation via a network of connected furnaces with greater intelligence (Fig. 4).

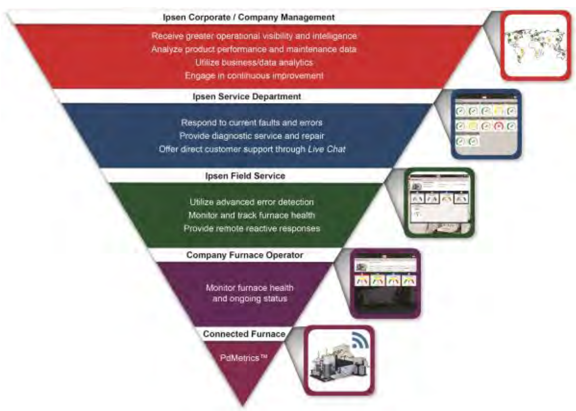

Figure 4: This chart illustrates the degree to which having a connected furnace positively a company's operations.

Take, for example, how the four primary features operate when monitoring the necessary critical data for the hot zone:

Maximum Equipment Performance
To ensure maximum performance of the hot zone, parameters such as resistance to ground, heat loss, open circuits and hot zone cleanliness are monitored. This, in turn, helps avoid arcing, which can damage the heating elements; ensures proper heating uniformity; and prevents high-energy consumption by the hot zone.

Diagnostic Helper
The Diagnostic Helper offers leak diagnostic procedures and an Ask the Expert feature to help furnace users better determine the cause of any problematic symptoms. It also offers several valuable resources, such as tips on maintenance troubleshooting, valve troubleshooting sequences and more.

For example, if a furnace experiences difficulty attaining vacuum levels (i.e., evacuating), it could be indicative of a leak. Users can then utilize the Diagnostic Helper's resources to determine the root cause before the leak slowly degrades the hot zone. On the other hand, if users suddenly begin experiencing outgassing, dirty parts and/or a lengthy pumpdown, they are able to use the weather station to see if the humidity levels are high enough to be the cause, or if these symptoms are indicative of a larger issue.

Intelligent Maintenance Routine
While it is still essential to have a set preventative maintenance (PM) program and corrective maintenance capabilities, the PdMetrics software platform builds upon existing maintenance and PM programs by incorporating an intelligent maintenance routine that provides an automatic maintenance reminder based on furnace performance and component usage. As a result, rather than replacing components according to how much time has passed, users are notified when the hot zone indicates the need for such maintenance. This then allows for the scheduled allocation of resources toward maintenance personnel, replacement parts and more. In addition, whenever an action is required and/or an error or anomaly is experienced by the furnace, the software platform will maintain a log of all the errors or issues ever experienced by the furnace.

Rounding out the ability of this software platform to provide an intelligent maintenance routine is its incorporation of calibration due dates. Accordingly, it takes note of when calibration is needed and provides enough time in advance to plan so that production can continue running without interruption.

Optimize Furnace Usage
Finally, users are able to continuously improve their furnace usage, as well as experience increased operational visibility. With the software platform's capability for integrating with multiple furnaces, as well as smart connectivity that allows users to receive alerts via email and/or text message, it has become increasingly simple to not just monitor multiple furnaces within one location (Fig. 5), but to also monitor multiple furnaces within different facilities – thus connecting factories globally in a way not possible before.

Figure 5: The dashboard allows users to monitor multiple furnaces at once. Whenever an action is required or an error is experienced, it is signified by a yellow caution or a red danger warning sign.

By analyzing the data gathered, users are better able to implement any necessary improvements or adjustments that will help refine and enhance the equipment's performance, as well as more effectively delegate resources (e.g., parts, personnel) according to overall needs.

The Maintenance Spectrum

To fully understand the emergence of predictive maintenance and its many benefits, it is also important to look at the two common forms of maintenance used today: corrective and preventative maintenance. Each maintenance strategy possesses it owns requirements and is often performed in conjunction with another form of maintenance in an effort to maintain production levels, as well as control – if not reduce – maintenance costs.

Corrective Maintenance
Considered one of the most basic approaches to maintenance, corrective maintenance is typically employed after a furnace fails to function correctly. As such, corrective maintenance often involves looking at the furnace's common symptoms to determine the probable causes of failure and, ultimately, correct them [1].

With the performance of corrective maintenance there are a few inherent disadvantages; the primary disadvantage is that it permits failures to occur. As a result, one is unable to completely avoid disruption to production, and it also becomes increasingly difficult – and costly – to reduce the amount of time needed to address the issue as one must be prepared at every moment for something to go wrong. This means having a wide array of spare parts on hand at all times, having the storage space to keep the parts, paying overtime wages for maintenance personnel to correct the issue and more – all of which can lead to low profitability.

Preventative Maintenance
Preventative maintenance, on the other hand, involves regular inspection and maintenance of the furnace equipment before any major failures occur. Having a preventative maintenance (PM) program in place is a key part of protecting one's equipment and generally includes regular inspection, equipment servicing, repair and replacement. Overall, PM programs allow companies to schedule downtime in advance, and they also help provide predictable, annual maintenance costs [2].

Preventative maintenance differs from corrective maintenance in that, rather than waiting for failures to occur before fixing them, it involves regularly preventing errors before they occur and keeping the furnace in excellent working condition. As such, preventative maintenance is often considered an effective method for protecting one's equipment and helping prevent unplanned downtime. Preventative maintenance can be divided into two sub-categories: time-based and condition-based maintenance.

Time-Based Maintenance
Time-based maintenance can be simplified as waiting for a specific trigger to occur before implementing the preventative action. The trigger can be based on a number of items – the amount of time passed, lead times, production quantities, etc. A common example of time-based maintenance is getting the oil in your car changed, as this action is performed at a fixed interval of time and/or according to a certain mileage.

This form of maintenance, though, also possesses its own disadvantages. For example, parts with low wear are exchanged according to this time-based principle, meaning they will need to be replaced more frequently. As a result, a larger number of low wear parts will need to be purchased and stored in order to prevent unnecessary downtime – all of which leads to increased costs. In the end, time-based maintenance is best utilized when the expenses it creates are lower than the costs that would occur for unplanned downtime situations or another form of maintenance, such as corrective maintenance [3].

Condition-Based Maintenance
Not too different from time-based, condition-based maintenance also relies on a trigger for indicating when preventative action is required. In this case, the trigger is the desired condition of the equipment. Inspected at regular, time-based intervals, wear-related conditions are recorded either with sensors or through human inspection and then compared against the required wear allowed for safe operation. If that value is exceeded, then maintenance of the necessary parts and/or systems must be carried out [4].

One such example of condition-based maintenance is replacing car tires when the minimum tread depth falls below the prescribed preset limit. Or when working with a heat treatment furnace, another example would be adjusting the pump water miser when the roughing pump's operating temperature falls outside the recommended limits.

With this form of maintenance, though, come some limitations. One such limitation being that, if a limit is exceeded, maintenance must be immediately performed. This leads to unpredictable maintenance periods, as well as makes it necessary to have a fair amount of spare parts in stock at all times – both of which result in increased personnel and storage costs. Similar to time-based maintenance, condition-based maintenance is worthwhile only when the expenses are reasonable in relation to the overall benefits, as well as in relation to the cost of other forms of maintenance.

Download Ipsen's detailed preventative maintenance checklists: http://bit.ly/IH-WP-2

Predictive Maintenance

The goal of predictive maintenance is to apply analytics to detect a risk of failure, thus helping prevent the failure before it ever occurs. The ideal predictive maintenance program often incorporates a well-balanced mix of predictive, preventative and corrective maintenance in order to best maintain equipment. However, it is the addition of predictive maintenance that helps create a cost-effective program.

By monitoring the furnace, its performance and other parameters, predictive maintenance provides key data that can be analyzed in order to determine when maintenance should be, or will need to be, performed – thus providing a heat treatment furnace that is capable of performing *what ifs*. In addition, this data can be used to augment the furnace's performance, efficiency and reliability. As a result, predictive maintenance is, in many ways, an enhanced extension of the condition-based preventative maintenance system.

However, in contrast to the other forms of maintenance, predictive maintenance allows for an all-encompassing planning of available resources, thus helping minimize unnecessary personnel, storage and spare parts costs. In addition, it is effective at identifying problems that occur between scheduled inspections. Predictive maintenance systems also generally carry a corresponding high benefit-to-cost factor, resulting in a specialized solution for the most essential components of a larger system – in this instance, a heat treatment furnace.

In the end, the integration of predictive maintenance provides a smart, connected furnace capable of monitoring in-service equipment to capture data that assists in refining furnace operations and reporting when service will be needed. Through analysis of the critical furnace data, predictive maintenance software can also identify maintenance trends, deteriorating conditions and more. This, in turn, helps furnace users plan ahead – whether that means scheduling someone to perform maintenance or ensuring the required furnace parts are in stock. Furnace manufacturers that utilize predictive maintenance are also able to gather data on the furnace's overall performance, which assists with continuous product improvement and future innovations.

Find more helpful tips on maintenance, including how-to videos and expert recommendations, at *The Ipsen, Harold* blog: www.IpsenHarold.com

The Convergence of the Internet of Things and Big Data

Improved operation is one of the key driving forces behind the many actions and decisions various businesses make. Demonstrating as much, the International Data Corporation (IDC) recently performed a survey among business and operations professions that concluded: "the leading driver of Big Data and analytics projects is 'product or service improvement and innovation'" [5].

To understand the growing development of such projects, one must understand the convergence of the Internet of Things and Big Data.

Understanding the Internet of Things

The term the Internet of Things was first coined in 1999 by Kevin Ashton, then co-founder and executive director of the Auto-ID Center, as a way to describe how physical objects are connected to the Internet:

> "Today computers – and, therefore, the Internet – are almost wholly dependent on human beings for information. Nearly all of the roughly 50 petabytes (a petabyte is 1,023 terabytes) of data available on the Internet were first captured and created by human beings – by typing, pressing a record button, taking a digital picture or scanning a bar code […] The problem is, people have limited time, attention and accuracy – all of which means they are not very good at capturing data about things in the real world […] If we had computers that knew everything there was to know about things – using data they gathered without any help from us – we would be able to track and count everything, and greatly reduce waste, loss and cost. We would know when things need replacing, repairing or recalling, and whether they were fresh or past their best" [6].

While the Internet of Things (IoT) was coined in 1999, it wasn't until 2010 that the concept started to gain popularity. Overall, the IoT includes connections beyond the industrial context, such as wearable devices on people – meaning physical objects are linked through wired and wireless networks (e.g., a Fitbit[1], which monitors different aspects of one's health and records that data via a network connection).

Defining Big Data

So if one approaches the IoT as a multitude of Internet-connected sensors that are attached to a range of 'things', Big Data, then, is a term for the massive amounts of data these 'things' generate. Take a smartphone, for example; if you carry one around with you regularly, many of your frequent activities (both physical and within the phone) can be tracked, analyzed and acted upon. The data that your smartphone activity creates is considered Big Data.

Big Data is characterized by the four Vs: velocity, volume, variety and veracity (i.e., accuracy) (Fig. 6). To put it simply, "connected, sensor-instrumented industrial devices are yielding data" rapidly (velocity), in large amounts (volume), in a mixture of "structured, semistructured or unstructured" information (variety) and this data can be "noisy and of uneven quality" (veracity), meaning certain data can be more accurate than others depending on its origin [7].

Figure 6: Illustration of the four primary characteristics of Big Data.

This data is then utilized in analytics initiatives, such as predictive maintenance, to "[discover] early signals that predict machine failure to determine priorities for asset maintenance or anticipating a shift in demand that will impact operations delivery capability" [8]. All of this, in turn, contributes to improved operations through predictive maintenance's utilization of the IoT and Big Data.

Internet of Things: Predicted Growth and Possibilities

The IoT – whether it's for consumer or industrial applications – has the ability to transform the ways companies operate. After all, integrating complex physical machinery with networked sensors and software for data trending and analysis contributes to product development, enhanced maintenance strategies, etc. However, it also opens the door to a multitude of possibilities and new opportunities for growth.

As more companies begin to realize the possibilities of the IoT, companies will continue to see it emerge in ways that positively impact the productivity, efficiency and operations of industries around the world. Over time, physical devices and the manufacturing process will become one entity as the IoT and integrated machines become more prevalent. In other words, the process itself will eventually become part of the physical, integrated system.

Take industrial applications, such as gear manufacturing, for example. Currently, there are multiple steps and physical devices that make up the process of manufacturing a load of gears – heat treatment, machining, molding, etc. However, with the application of the IoT, all of these processes and systems will become interconnected. One day, companies will be able to start with a piece of material that knows who the end customer is, and once it is put into a machine, any abnormalities or changes from the standard process will be recorded. The technology will move the part from one process to the next as part of an automated system, and each integrated machine will track the necessary information. All of this data will then be accessible in a central location so the IoT system can analyze the manufacturing process and determine ways to reach peak efficiency, lean manufacturing objectives, etc. With this end goal in mind, the intention of such technology as Ipsen's PdMetrics software platform is that it will, in the future, fit into other IoT systems – a piece of a much larger puzzle.

Conclusions

What if your furnace could tell you that it isn't operating correctly?

Such a simple, yet impactful question is the driving force behind the constant evolution of maintenance methods and procedures. And it is this constant evolution that is necessary if one is to successfully increase production and enhance operations while simultaneously reducing manufacturing costs and unplanned downtime. One answer to this *what if* – as well as the next step on the maintenance evolution path – is predictive maintenance.

[1] Fitbit is a registered trademark and service mark of Fitbit, Inc.

As we advance down this path, many companies are learning that "predictive maintenance analytical models can guide managers to better decisions on how to deploy assets and when to maintain them to ensure safe, efficient, and optimized operations" [10]. What Ipsen is discovering is that the PdMetrics software platform for predictive maintenance provides a new, innovative solution for the thermal processing industry thanks to its ability to ensure maximum equipment performance via real-time monitoring of critical systems. Benefits include predicting and scheduling service based on the furnace's operational history; reducing unplanned downtime with the ability to determine inventory needs in advance and correct problem areas before they become critical; and integrating the software platform with the current service department to better track and schedule regular preventative maintenance activities.

In the end, the PdMetrics software platform is a key example of how predictive maintenance is emerging as a tool for analyzing equipment performance and maintenance needs, as well as how the Internet of Things and Big Data have begun to impact the world of heat treatment.

For more information, contact Sales at Sales@IpsenUSA.com or 1-800-727-7625, or visit www.IpsenUSA.com.

References

[1] Grann, Jim, "Protecting Your Vacuum Furnace with Maintenance," Ipsen White Paper, *Industrial Heating* (2015), http://www.industrialheating.com/ext/resources/IH/Home/Files/PDFs/15March-IH-WhitePaper_MaintenanceTips_final.pdf.

[2] Ibid.

[3] Ahmad, Rosmaini, and Shahrul Kamaruddin, "An overview of time-based and condition-based maintenance in industrial application." *Computers & Industrial Engineering*, Vol. 63, No. 1 (2012), pp. 135-149.

[4] Ibid.

[5] Morris, Henry D. *et al.*, "A Software Platform for Operational Technology Innovation," International Data Corporation (2014), pp. 1-17.

[6] Ashton, Kevin, "That 'Internet of Things' Thing," *RFID Journal*, Vol. 22, No. 7 (1999), pp. 97-114.

[7] Morris, pp. 7.

[8] Ibid., 1.

[9] Ibid., 4.

[10] Ibid., 16.