Improving chemical production processes with IIoT and AI technologies

WHITEPAPER

Filter presses supported by Industrial Internet of Things (IIoT) and Artificial Intelligence (AI)-technologies – How new control and monitoring mechanisms add value to filtration processes for a wide range of chemical applications.
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Abstract

Efficient filtration is an essential process step in the chemical industry if you want to guarantee consistently high product quality. The filter press has long been established as one of the most common products for filtration, but extensive changes over the decades mean that today’s version bears scant resemblance to the first presses. In a field highly receptive to innovation, it is hardly surprising that the Industrial Internet of Things (IIoT) and Artificial Intelligence (AI) technologies have now come to bear on filter press development. One company at the forefront of applying latest IIoT advances to classic separation technology is the international technology group ANDRITZ. Their automation solutions for filter presses draw on new mechanisms and features that not only increase product quality but also decrease operating costs by optimizing processes.

So what makes a filter press intelligent? The key distinguishing features include monitoring of dry substances, oil and filtrate quality, as well as intelligent washing cycles and pressure control. These features enable operators to increase efficiency, reduce downtime, and enhance safety and monitoring functions. For example, a Smart Sensor may be fitted inside the filter press to monitor the press and constantly compare the values reported with the nominal values. The filter press can then be stopped automatically if any deviations from the norm are sensed. The sensor can also increase efficiency, for example by suggesting an automatic washing cycle to keep the quality of the end product at a consistently high level.

Furthermore, the filter press can be programmed to shut down in case of a loss of pressure – a feature that massively increases operating safety. In addition, intelligent technology facilitates constant measurement of the oil levels and oil quality, thereby ensuring smooth operations and reducing OPEX by avoiding unnecessary oil changes. Damage to the equipment is also prevented by ensuring lubrication stays at a functional level. Another key efficiency driver is the monitoring of dry substance by Smart Sensors positioned inside the filter press during the process. This enables the operator to stop filtration at the right time and reduce fluctuations in the cake moisture content.

And a final aspect is the enhancement of usability by applying intelligent filter elements: Leading technologies that have to be mentioned in this respect are the intelligent filter plate and the smart filter cloth developed by ANDRITZ. The Metris SmartFILTERCLOTH is tagged with an RFID chip to help monitor use and indicate the right time to replace cloths, while the LENSER filter plate facilitates an enormous reduction in cycle times.

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Introduction

Issues related to filter press operation

Filter presses are batch-type separators for the solid/liquid separation of suspensions and belong to the group of cake-forming separators. The filter press has the highest separation efficiency of all separation units and achieves the best results in terms of dry substance content. It can be operated as a chamber or membrane filter press in order to meet the user’s demands as flexibly as possible. One reason the filter press is favored by the chemical industry is the dry substance content that can be obtained. As the filter press forms a filter cake, it is also possible to remove ultra-fine particles, which provides a pure filtrate and a high yield, making the processes highly efficient. In the chemicals industry, the main priority is the purity of the product (filter cake or filtrate). This can be achieved in a filter press via cake-washing techniques, as the unwanted components detach from the filter cake. Another advantage of the filter press is the lower operating costs compared to decanter centrifuges, for example.

That said using a filter press also comes with certain downsides. One is the considerable personnel needed to supervise emptying the machine and inspect the filtration area during emptying, as well as for machine maintenance. Another disadvantage of cake-forming filtration is that the filter cloths become more contaminated the longer they are in use, negatively impacting separation efficiency. The quality requirements for hydraulic oil mean that operators also frequently face challenges resulting in essential oil changes and subsequent downtime.

So, would it be possible to ensure that the pros of a filter press always outweigh the cons? The international technology group ANDRITZ decided to explore how to apply the technologies of Industrial Internet of Things (IIoT) and Industry 4.0 to address these issues and create a genuinely 'intelligent' filter press. The basis is to equip a filter press with the Metris addIQ control system and the first clear option was to deploy Smart Sensors. They are particularly helpful in this context as they facilitate preventive maintenance and risk mitigation at an early stage. Similarly, the solutions generate data flows that inform the plant engineers and operating personnel about the current status of the machine at all times. This allows a more efficient use of personnel and provides a better basis on which to plan maintenance work thanks to the fact that the intelligent filter press supplies information on any deviations from the norm.

This paper focuses on an array of performance-driven features of the intelligent filter press, each of which are examined in detail below:

- Intelligent cloth washing
- Intelligent filter element for precise control
- Cloud-based monitoring (filter press app) and RFID technology for filter-cloth monitoring
- Intelligent pressure monitoring for operating safety
- Optimizing the performance of multiple filter presses and ancillary equipment
- Optimized hydraulic oil control

1 www.andritz.com/metris-addiq
Intelligent cloth washing

Filter elements and cloths are often clogged during filter press operations and have to be cleaned with high pressure after a certain operating period that depends on the suspension being dewatered. A standard cycle for high-pressure cloth washing is daily to once a week, based on a specific number of cycles, if the dewatering process is to reach the targeted values.

Intelligent pressure monitoring

The feeding pressure sensor is also used to take a close look at the pressure increase at the beginning of the filtration process. If the pressure rises faster than compared to normal conditions at the beginning of pressure filtration, the control system informs the operator that a washing cycle may be needed to improve filter press performance. This keeps the filter cloths clean, the separation efficiency of the filtration process remains at a high level, and the dry substance in the filter cake stays at a consistently high level.

In cake-building filtration processes, the cake forms and the pressure rises, but this takes place quite slowly (normally from 0 to 2 bar in around 15 minutes depending on the application). If the cloths are clogged at the beginning of the filtration cycle, the pressure can rise faster, often to 5 bar or more in 15 minutes, so a high-pressure washing cycle is needed.

![FIG. 1 Online pressure monitoring](image-url)
Intelligent angle monitoring

The other way to detect the need for a washing cycle is to monitor the angle of the shifting plate. The shifting plate is aligned with the filter plate pack on a regular basis. However, the contaminants from the filter cake and core drilling pollutes the sealing area of the filter elements during cake discharge. Every time the filter press is closed, the layer of contaminants becomes thicker and the shifting plate is no longer properly aligned.

A tilt sensor attached to the shifting plate in the intelligent filter press measures the angle deviation. If the deviation exceeds a predefined maximum value, the operator is encouraged to start a washing cycle.

Optimization of the washing cycle reduces cycle time and washing water consumption, increasing production capacity. It also avoids dirty sealing areas, preventing harm to operators and the environment. Optimized washing cycles also guarantee a longer lifetime of plates and cloths.

FIG. 2
Comparison of shifting plate alignment

Left: dirty cloths/plates
Right: clean filter plate
Intelligent filter element for precise control

The smart filter plate developed in collaboration with LENSER Filtration gets its intelligence from the two built-in sensors (see Fig. 5) that transmit electromagnetic waves. These waves influence the alignment of the water molecules along the dipoles (see Fig. 4) so that the sensor can calculate the energy required to align the dipoles with the aid of the dielectric constant. The amount of energy needed increases the more water there is in the filter cake.

Example of the dielectric constant:
Vacuum = 1, Sand = 4, Water = 81

Energy consumption over time can be reduced by determining the dry substance content.

The sensor, which is mounted as a surface sensor on the dimpled area of the filter element, is placed directly underneath the filter cloth in direct contact with the filtration chamber. As the sensor is clamped in place mechanically on a milled surface, no screws are needed to secure it. Two to four sensors can be installed per filter plate, depending on operator preferences.

In order to absorb the forces occurring during filtration and subsequent pressing, the sensor is supported on a water-insoluble (hygroscopic) gel and can thus withstand the filtration pressures occurring in the filter press (4/7/15 bar).

No field

With field

Water ferro-electrics

Molecule Dipole

FIG. 4 Comparison of water molecules alignment

This clearly illustrates that the sensor requires much more energy the higher the water content.

FIG. 3 Smart filter plate

FIG. 5 Built-in sensors in filter plate
The sensor itself is made of a steel and ceramic composite material that is suitable for most media and can also be used in the food industry.

After 18 months in test operation, where initial calibration difficulties have been solved, the first test results obtained with the sensor in different industries display now stable results that differ from the lab measurements performed for comparison purposes by just ±0.3% (lab 25.1% DS, sensor 24.9% DS). The sensor is also proving successful in commercial tests currently being conducted at several customers’ facilities in different industries.

Measurement of the dry substance allows the operator to control filtration precisely and plan cycle times so that the filter press runs at optimum operating status at all times. Based on the measuring results, it was already possible to reduce the cycle time from 43 to 31 minutes with the same filtration results. This time gain results from a filling time that is five minutes shorter and a subsequent pressing time that is seven minutes shorter. And as shown in Fig. 7, the cycle time was reduced by 8% for an application within the mining and minerals industry.

**FIG. 6** Dry substance measurement

**FIG. 7** Graphical representation of cycle time reduction for an application within the mining and minerals industry
RFID technologies for filter-cloth monitoring

Clogged filter cloths can be a significant factor in terms of both costs and time, as scheduling replacements has always been an inexact science. The Metris SmartFILTERCLOTH uses a radio frequency identification system to track filter-cloth use and replacement to deal with the issue of filter-cloth operating time and clogging. An integrated RFID (radio-frequency identification) chip with a tracking system helps to monitor filter-cloth use. The first tests were conducted in South America at a facility operated by the world’s leading producer of iron ore and nickel.

The Metris SmartFILTERCLOTH allows the plant operator to establish an automated filter-cloth management system: The operator is then able to track the frequency with which a cloth is mounted in a filter press. As it gains experience, the software connected to the cycle time counter of the filter press itself is able to inform the operator which cloth has to be changed and when. If operators recognize any damage to the cloth, they are able to document the exact type and position of the damage, using a smart device or tablet. After that, they check out the cloth of the filter press and remove it as usual. Then the software summarizes the number of cloth changes based on the data collected and marks areas requiring unusually high maintenance for experts to check. Filter cloth management makes it possible to keep track of changing products on the same press helps you to keep an overview when changing the cloths.

For plant operators with several plants, the software is also able to create an interactive world map providing a global view of cloth management.

FIG. 8
Tracking the use of filter cloths on mobile devices
Intelligent pressure monitoring for operating safety

Intelligent pressure monitoring makes sure the filter press is always operating under safe conditions by measuring the hydraulic and feed pressure as well as the feed temperature. The PLC (Programmable Logic Controller) system used for this filter press function contains an algorithm, which calculates the right hydraulic pressure according to feed temperature as well as pressure and safety regulations. The correct hydraulic pressure depends on the size of the filter press, but is generally between 315 and 350 bar. If there is an overload, i.e. pressure values of 450 bar or more, the filter press switches off itself. Then the fluid pressure has to be reduced to lower the hydraulic pressure. If the pressure is not reduced, the emergency overload valve of the hydraulic line is triggered and relieves the pressure in the filter press so that it is always running under safe conditions.

As a result of the additional control of the feed pressure, the algorithm prevents inadmissible operating conditions for polypropylene filter elements inside the filter press.

Complying with this algorithm reduces the risk of contaminating the working environment with suspension. In addition, plates and cloths have a longer lifetime when operating at ideal feed and closure pressure as well as controlled temperature conditions. Fig. 9 shows the feed temperature over the feed pressure. An easy rule to remember is the higher the feed temperature, the lower the feed pressure. This means that the algorithm will reduce the feed pressure if the process changes and the feed suspension is higher than expected.

![FIG. 9 Feed pressure / temperature ratio](image-url)
Another key features of Industry 4.0 is app-based monitoring of filter press conditions. The use of Metris addIQ Monitoring enables the operator to monitor the health status of the machine 24/7 from anywhere in the world. The filter press app for Windows, Android, and iOS (smartphones, tablets, and PCs) is able to direct access to process live data, and to machine-related documentation. This enables the operator and plant managers to observe filter press behavior. Different KPIs are shown in one step on the filter press radar screen. If any intervention is needed, the operator can go to the filter press and take a look. These features are combined with an automatic e-mail notifier for the most critical process alarms, allowing the operator to take action immediately if values differ from the norm. Additionally, automatic reports are generated (every shift, every day, every month), which include process values and corresponding trend curves, and these can also be sent to an e-mail recipient.

**FIG. 10** Hydraulic closing pressure diagram – showing the hydraulic pressure system which always rises with the feed pressure

**FIG. 11** Filter press app to visualize the key process parameters in real-time
Optimizing the performance of multiple filter presses

In operations with multiple filter press machines, operators make decisions on when is the best time to take one of the machines out of operation for washing or cloth change. This decision affects overall production and water consumption. At this level, operators need to consider the efficiency of filtration operations as a whole. When there are more than four filter press machines in the plant, it can be very complex to maintain an overview of the entire operation. Operators have to consider many aspects of the operation constantly, such as bottlenecks in throughput, availability of water, and the operating status in upstream and downstream equipment. The automation solution Metris addIQ ACE for filter presses, part of Metris addIQ Optimizing², considers all the aspects mentioned. The automation solution automates the decision-making process, and optimizes the entire filter press operation – uniformly and holistically. Metris addIQ ACE for filter presses is equipped with Artificial Intelligence technology for the needs of each filter press so that each machine is aware of what is happening throughout the operation.

This system takes the efficiency of each filter press into account, collects information from upstream and downstream operations and makes intelligent decisions to maximize production throughput, minimize water consumption, and increase overall filtration efficiency. The Metris addIQ ACE for filter presses looks at the operational management of the filter presses as a complete system, thereby also optimizing the ancillary equipment, such as feed pumps, to ensure such conditions as excess power consumption are avoided.

In the Metris addIQ ACE for filter presses system, the filter press is reduced to its basic modes: running, washing cycle, cloth change, and idle/maintenance. The Metris addIQ ACE for filter presses system collects data from every sensor in the filter presses and calculates an efficiency value for each filter press in the pool. If any press is below the target value, one of the idle presses will change to running mode.

![FIG. 12](image-url)  
**FIG. 12**  
Scheme Metris addIQ ACE for filter presses

² [www.andritz.com/metris-addiq](http://www.andritz.com/metris-addiq)
The less efficient filter press will start a washing cycle if Metris addIQ ACE for filter presses finds an available washing water pump as well as enough washing water (based on sensor values for water level and pump data). When the washing cycle is complete, the filter press will switch to idle/maintenance mode until it is needed to replace another filter press in the system. This requires no operator intervention at any time during the process. Metris addIQ ACE for filter presses enables the operator to reduce operating costs and keep the equipment in optimum condition at all times. The system can increase throughput because set values are calculated by the AI-technologies and so the filter presses are programmed to the best operating conditions to meet these demands.

**Optimized hydraulic oil control**

Filter presses need a large quantity of high-quality hydraulic oil to operate. Normally, an oil change is required every year to keep filter press operations running smoothly. An oil change requires production to be stopped, thereby incurring production losses of one to two days.

The intelligent filter press uses Smart Sensors which are able to monitor particles and humidity in the hydraulic oil used in the filter press. As the Smart Sensors are connected to Metris addIQ Monitoring³ and Metris addIQ Connect⁴, the filter-press operator is able to monitor the hydraulic oil quality as measured online by the Smart Sensors. Metris addIQ Optimizing, which is an analyzing tool that identifies opportunities to improve the equipment’s performance, then draws on its ability of long-term data trending with analytical software, collecting and analyzing pre-defined KPI’s and the data gathered to predict future incidents by connecting and analyzing this data.

By using a trending curve, the control system informs the operator when an oil change is required, enabling predictive maintenance. The operating parameters measured and monitored also include maximum and minimum values for temperature, humidity, and particles. If the oil characteristics fall below the previously defined minimum quality requirements, either the operator is informed by an automatic email notifier or the filter press will stop operation by itself to prevent any damage to the valves, pumps, hose lines, or hydraulic cylinders.
Conclusion

The excellent separation efficiency and results in terms of dry substance, combined with the fact that the filter press is suitable to treat a variety of suspensions, make it a reasonable solution for a large number of chemical applications. In addition, the filter press achieves particularly high product purity of both the filter cake and the filtrate – an essential factor in the chemical industry. An intelligent filter plate in combination with the intelligent cloth washing and optimized hydraulic oil features contribute substantially towards maintaining the efficiency of the filter press at a high level at all times. In addition, the general operating safety of an intelligent filter press is enhanced significantly by using intelligent pressure monitoring.

The advantages of the filter press in terms of high separation efficiency and achievable dry substance can be enhanced by applying innovative automation solutions combined with IIoT and AI-technologies. Especially features such as the intelligent cloth wash, the Metris SmartFILTERCLOTH, and the continuous oil quality measurement enable predictive maintenance. In addition to better predictability of maintenance and servicing, operational safety is also increased, since it is possible to recognize and correct problems at an early stage.

The Industry 4.0 modules in combination with Metris addIQ Monitoring and the filter presses app allow real-time monitoring of filter press data in a configurable environment. This enables various user groups in a company to be informed about the data that is of interest or relevant to them specifically.

All of the features together mentioned in the present paper result in greater safety, higher efficiency, and lower operating costs. What is more, there are many more ways available to control the filter press – without the operator actually being on the spot. Metris addIQ Monitoring combined with the filter press app makes real-time monitoring of the mechanical status of the filter press and the process data much easier – all this regardless of where the press is located when the filter press app is used.

Promising results from commercial tests have shown that the strategy of using the latest developments from IIoT and Industry 4.0 to further develop the filter press is a successful one.

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ANDRITZ GROUP
ANDRITZ is an international technology group providing plants, systems, equipment, and services for various industries. The company is one of the technology and global market leaders in the hydropower business, the pulp and paper industry, the metal working and steel industries, and in solid/liquid separation in the municipal and industrial segments. Other important fields of business are animal feed and biomass pelleting, as well as automation, where ANDRITZ offers a wide range of innovative products and services in the IIoT (Industrial Internet of Things) sector under the brand name of Metris. In addition, the company is active in power generation (steam boiler plants, biomass power plants, recovery boilers, and gasification plants) and environmental technology (flue gas and exhaust gas cleaning plants) and offers equipment for the production of nonwovens, dissolving pulp, and panelboard, as well as recycling plants.

ANDRITZ stands for passion, partnership, perspectives and versatility – core values to which the company is committed. The listed Group is headquartered in Graz, Austria. With almost 170 years of experience, 29,600 employees, and more than 280 locations in over 40 countries worldwide, ANDRITZ is a reliable and competent partner and helps its customers to achieve their corporate and sustainability goals.

ANDRITZ SEPARATION
ANDRITZ Separation is one of the leading separation technology specialists with the broadest technology portfolio in solid/liquid separation. The industries served include sectors ranging from environment to food, chemicals, and mining and minerals. The comprehensive product portfolio for solid/liquid separation comprises mechanical technologies such as centrifuges, filters, screens, thickeners, or separators, and thermal technologies such as dryers or coolers. The service sector focuses on customer support through local presence, prompt delivery of spare and wear parts, process monitoring and optimization, as well as operator training. In addition, the Separation business area offers technologies and services for the production of animal feed and biomass pellets.