Solutions for predictive maintenance and condition monitoring

smart plastics

for Industry 4.0 energy supply

- **smart plastics** components are equipped with connectivity and sensors to make complex automation solutions capable of "Industry 4.0"
- **smart plastics** offer two options:
  i.Sense - condition monitoring and
  i.Cee - predictive maintenance
- Make maintenance and repair of your machines more efficient and cost-effective with **smart plastics**
- **smart plastics** reduce failures

smart plastics components are equipped with connectivity and sensors to make complex automation solutions suitable for "**Industry 4.0**"

smart plastics
Industry 4.0 energy supply

In the future, automation solutions across different industries will all have digitalisation. If you want to entirely network the machines in your manufacturing plant with the internet of things (**IoT**) in order to be **Industry 4.0**-compatible and optimise such items as maintenance, you will need time and money. A digitalisation strategy that begins by connecting and networking individual assemblies and components is faster and costs much less. Plant operators benefit immediately from the connectivity of smart components: status monitoring for automated plant can be implemented in real time without additional personnel, and maintenance can be organised predictively. smart plastics offer two options: the simple and rather analogue condition monitoring **i.Sense** (sense = perception), for integration with maximum safety. For the complete networking of the machines with the internet (**IoT**), the predictive maintenance **i.Cee** (Cee, derived from "see") is just right.

i.Sense - condition monitoring

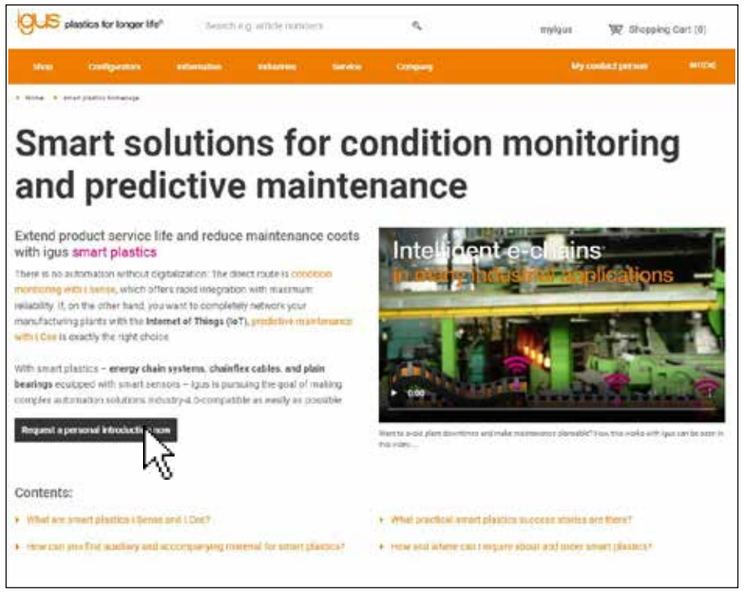
- Simplest, fastest way for a self-monitoring smart plastics product, by attachment of sensors
- Alarm or message when a previously defined limit value is exceeded
- Values outside defined limits can directly trigger a system shut-down

i.Cee - predictive maintenance

- Sensors and software help to create a system for dynamic service life calculation and optimal maintenance times
- Wide variety of designs, offering a high degree of individuality
- Maximum system and user safety and product service life

Typical industries and applications

● Harbour installations ● Cranes ● Automotive production ● Bulk Handling ● Logistics ● Semi conductor industry



smart plastics Website

Always stay up to date. New products, new techniques, new applications

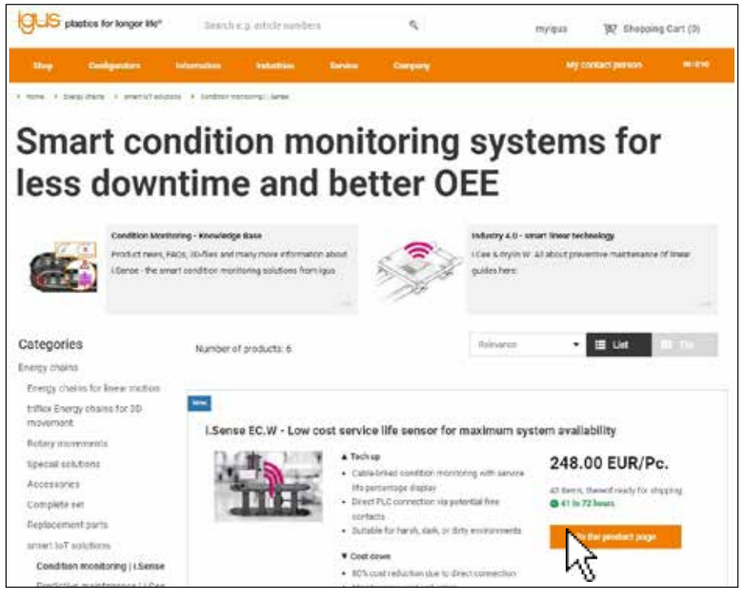
▶ **www.igus.eu/smartplastics**

smart plastics brochure

Overview with the following topics:

- Condition monitoring (**i.Sense**)
- Condition monitoring products
- Condition monitoring application examples
- Predictive maintenance (**i.Cee**)
- Application examples for predictive maintenance
- Predictive maintenance data flows

▶ **www.igus.eu/smartplastics**



smart plastics online shop

Order systems with push/pull force monitoring and breakage detection online as a complete package ▶ **www.igus.eu/smart-plastics-shop**

The igus® white paper on predictive maintenance

Clarifies the distinction between condition monitoring and predictive maintenance

- What igus® condition monitoring (**i.Sense**) means
- What igus® predictive maintenance (**i.Cee**) means
- What technology is behind both systems
- What the two systems offer industrial energy supply

▶ **www.igus.eu/smartplastics**

Condition monitoring - i.Sense

- igus® products for condition monitoring
- Detects machine status regularly or continuously
- Uses fast switch-off to avoid crashes

If smart plastics are used for condition monitoring, they immediately report any unexpected operating state, switch off the system, or sound an alarm. Industrial manufacturers use this function to minimise system failures and downtime. ► www.igus.eu/condition-monitoring

Control cabinet

- Simple module installation on top-hat (DIN) rail
- Integration into the existing plant control system via NC contacts
- 24V DC voltage supply

i.Sense:module

- Evaluate all sensor data based on igus® algorithms
- Inform the plant controls in real time of any mechanical faults that occur

Sensor units

- **IS.CF.P** tensile force monitoring for cables
- **IS.CF.Q** cable quality monitoring
- **IS.CF.D** data transmission monitoring

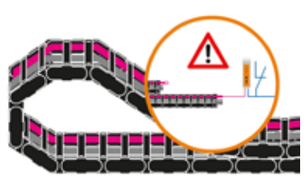
i.Sense
Condition monitoring

Condition Monitoring
The concept of condition monitoring is based on a regular or constant recording of the machine condition by measuring and analysing physical parameters, e.g. vibration, temperature, position/ proximity. Condition monitoring pursues two goals: safety and machine efficiency. (Source: Wikipedia)

i.Sense:module

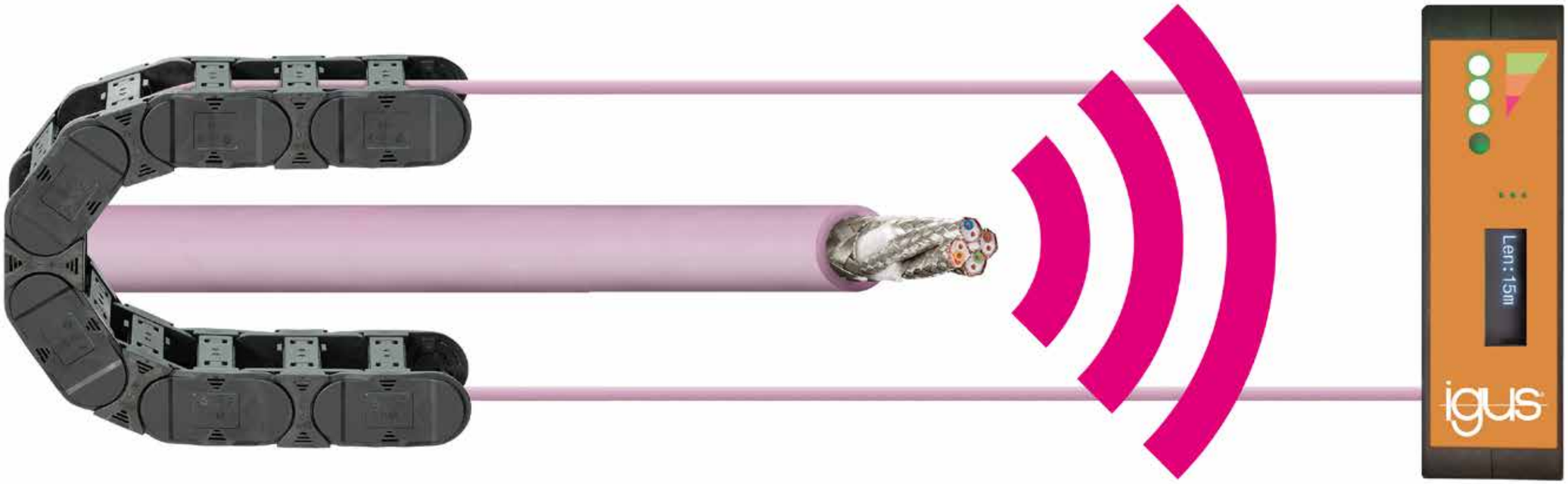
Sensor units

CF.P



CF.Q

CF.D



CF.D

i.Sense cable monitoring systems:

Tensile force monitoring for cables with i.Sense CF.P

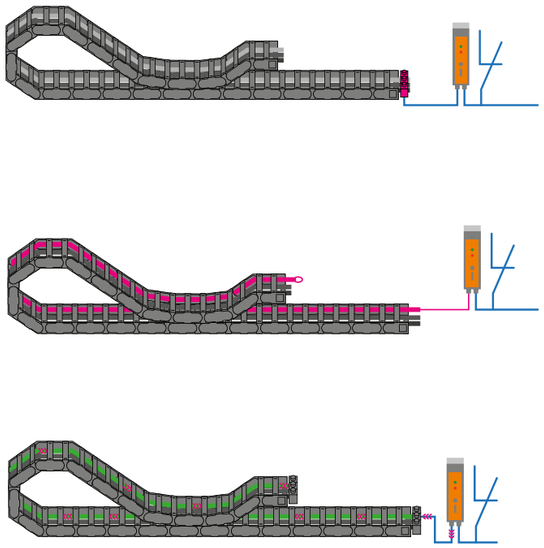
- Measures the forces directly at the strain relief element
- Triggers a shutdown by means of the NC contact if forces are excessive
- Cable damage caused by jacket abrasion is reliably avoided

Cable quality monitoring with i.Sense CF.Q

- Measures the quality of the cable cores
- Early notification via contact if core rupture starts

Data transmission monitoring with i.Sense CF.D

- The measuring is carried out on the actual used cores; no extra cores or sensor elements needed
- Identification of the alleged damaged cable area
- Early notification via contact, network or visual status display



System components of i.Sense CF.D

Acquire data - Evaluate data - Visualise data

- **Sensors:** A new measuring method determines the data transmission characteristics of the cables during operation. This means that no extra cores are needed.
- **Evaluation module:** Every sensor data is processed by the CF.D module during operation. If the transmission properties begin to deteriorate, this can immediately indicate the need for a cable replacement in good time avoiding plant downtime.
- **Dashboard:** The dashboard provides detailed information on the detected deterioration in transmission properties and shows the distance in meters of the affected cable section. In this way, maintenance work can be carried out specifically, promptly and quickly.

smart plastics | i.Sense in a packaging machine
i.Sense

i.Sense protects a modern packaging machine ...

Challenge

Sliced, packaged bread is an everyday product for many households. But it takes rather complex technology to make it that way. The bread must be carefully cut and securely packaged and sealed. GHD Georg Hartmann Maschinenbau is one of the world's leading manufacturers of systems for slicing and packaging foodstuffs. These operations require speed as well as precision.

Cutting-edge machines, such as the GBK 440, package up to 80 pieces of sliced bread per minute – less than a second for each. So it works with high strokes in a relatively small installation space. In particular, the energy chains with cables for energy supply, control and measurement are heavily stressed by the rapid movements. So all cables must be optimised for a minimum bend radius of just 63 millimetres. This places high demands on cable quality. Unfortunately, cable damage cannot be avoided entirely. They result in costly downtime, since the high throughput quickly adds up to large production backlogs.

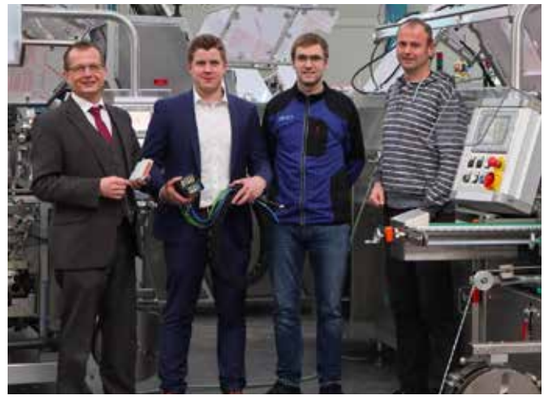
So GHD wanted a warning system that would detect failures in advance so that they could be prevented. It commissioned igus® GmbH, a manufacturer of lubrication-free high-performance plastics and fail-safe energy supply systems, to implement the system.

The solution

For energy chains, cables and plain bearing products, igus® has developed a product family in which sensors make plastic components intelligent. It is called smart plastics. The principle is simple: intelligent sensors record the status of the components involved and report it to the i.Cee module, which passes the data on – to the cloud, for example. igus® uses the CF.Q module for cable monitoring to avoid cable damage in such applications like the GHD Hartmann bread packaging machine.

The principle of the monitoring system is as follows: it assumes that two cables from a production batch behave in the same way when stressed and should therefore also approach their breaking point at the same time. So a second, identical cable is added to the measuring cable. The system continuously monitors the two additional cores. The device measures push/pull forces and detects the beginning of a damage very early by the changes in the electrical properties.

For this, igus® has collected a large amount of data from load tests and historical data from various application scenarios which are used to generate a comparative value for forecasting. The software can therefore predict just how many more work cycles a chain can handle without failure. The process data collected at the same time makes it possible to predict the remaining number of working days the chain has, so that companies can precisely plan maintenance and replacement.



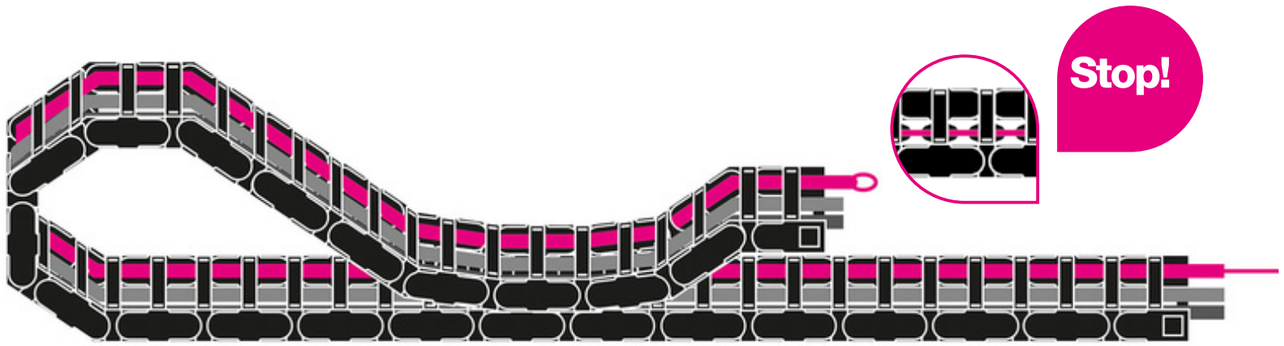
The result

The igus® CF.Q system is an integral part of the GBK 440 packaging machine. It allows the interval between maintenance sessions to be greatly extended. All data is evaluated in the customer control system and output as notifications on the Human Machine Interface (HMI).

This concept allows cables to operate far beyond the igus® guarantee period. The user company thus saves several thousand euros in maintenance costs each year. The i.Sense CF.Q's modern technology detects core ruptures before they occur, saving the user high downtime costs.

CF.Q - cable quality monitoring

- Measures the push/pull forces acting on the e-chain®
- Recommends shutdown of the equipment if a force limit is exceeded
- Prevents failure



i.Sense| Condition Monitoring
i.Sense

... and other exciting challenges

... sewage treatment plants...

Challenge

As the plant runs around the clock, and some of the time without any human presence, faults sometimes remain undetected for hours. Although the plant runs at a very slow speed, in the event of a failure it can lead to a total breakdown. This total breakdown of the energy supply system leads to significantly higher costs than a standstill for several hours, where the system can be put back into operation after a short maintenance period.

The solution with smart plastics

In this case the solution is the push/pull force monitoring system EC.P. This sensor continuously measures the force which the plant requires to move the energy supply system. If these forces change due to external influences such as ice, an animal or a tool forgotten during maintenance, the sensor detects this change and switches the system off immediately. This prevents expensive total damage to the sewage treatment plant.

... car plants

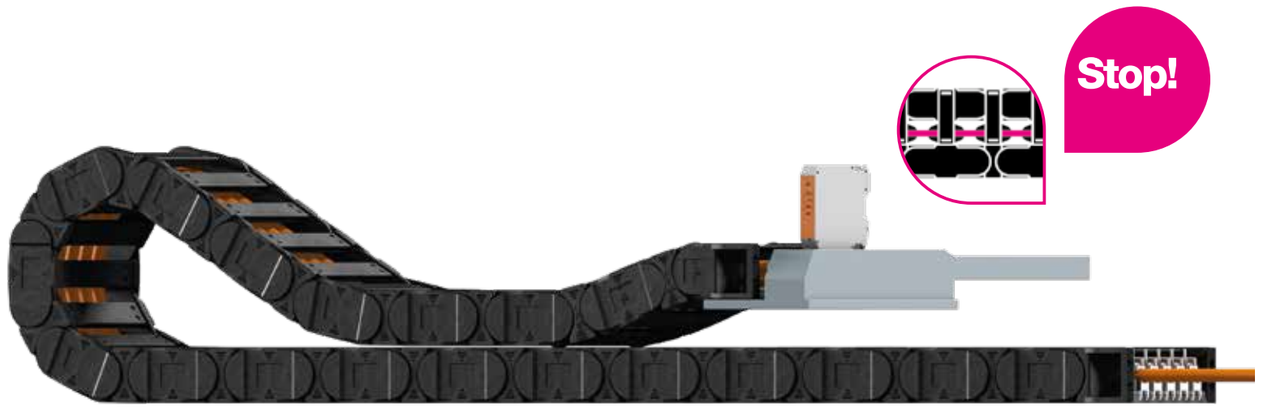
"A high price can be avoided."

To avoid unplanned breakdowns and plant shutdown, smart plastics from igus® are used on indoor gantry cranes for the automated handling of engine blocks at an Austrian automotive supplier. EC.B modules monitor the status of the e-chain®. In the event of a chain breakage, the machine is stopped automatically to prevent subsequent damage. Additional EC.W modules signal advanced wear of the e-chain®. The measurement of wear data means that a chain's remaining service life can be predicted and replacement can be planned at an early stage.

Read more about this application at

▶ **www.igus.eu/smartplastics**

The i.Sense system has been the standard in container cranes for many years.



EC.P - push/pull force detection for e-chains®

- Measures the push/pull forces acting on the e-chain®
- Recommends shutdown of the equipment if a force limit is exceeded
- Prevents failure

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Predictive maintenance - i.Cee

- Precisely predicts maintenance
- Prevents downtime or loss of quality
- Two options for data transmission: i.Cee:local / i.Cee:cloud

Both the service life calculation sensors mentioned above and the i.Sense sensor units for condition information provide data from which, in many cases, indicators of maintenance necessary to minimise the risk of product failure can be detected at a very early stage. Based on the experience gained in the 3,800m² test laboratory for plain bearings and energy transmission solutions, in combination with self-developed algorithms, the system alerts and notifies the user at an early stage about possible failure risks and/or the next maintenance date.

Offline: i.Cee:local / Online: i.Cee:cloud

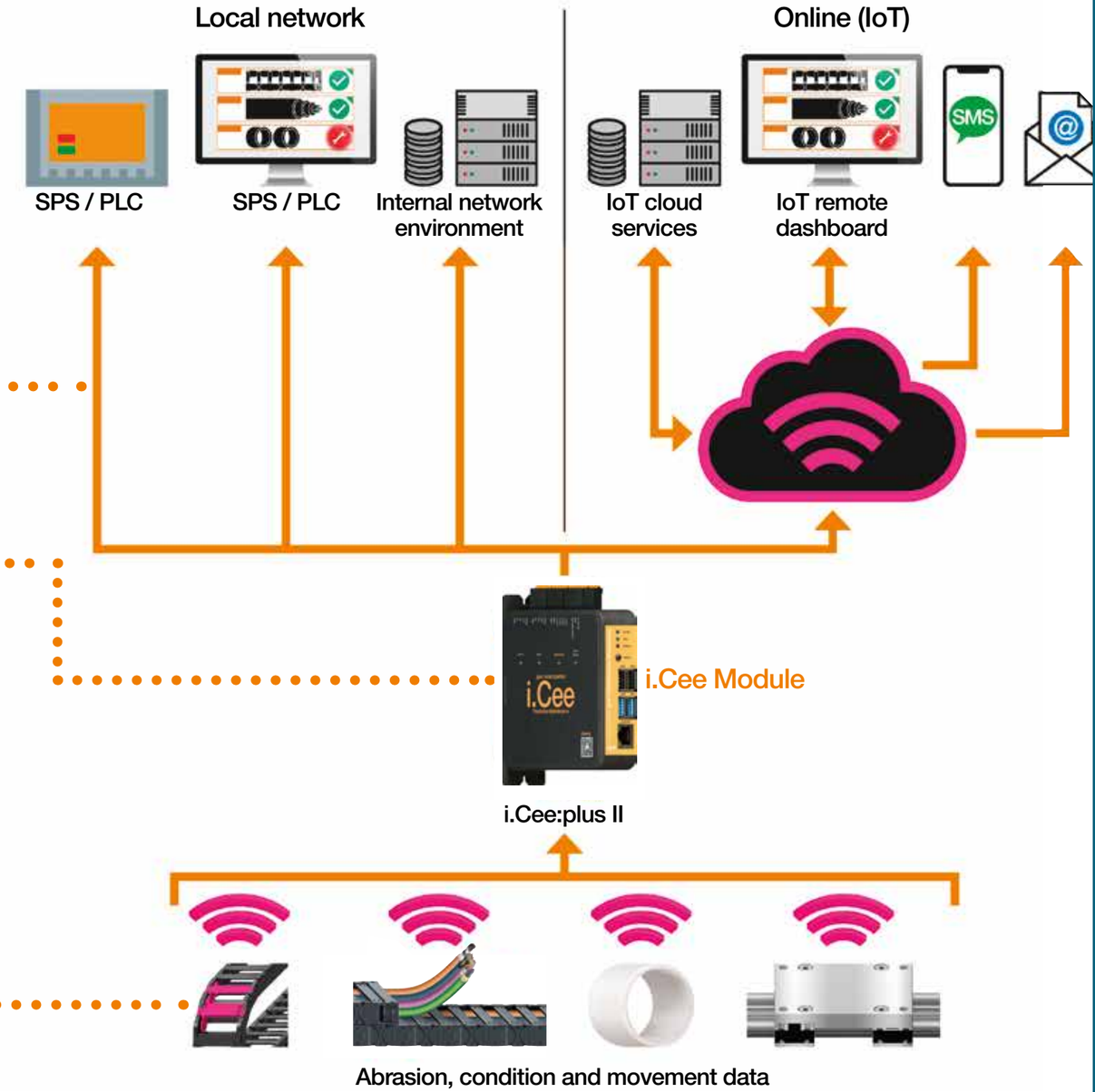
i.Cee hardware

Standard: i.Cee:plus II module

- Installation on top-hat (DIN) rail in control cabinet
- Storage and processing of sensor data
- Constant calculation of the product's service life
- Additional connection of i.Sense modules via USB possible
- Can be integrated into existing Industry 4.0 cloud solutions via IoT

Sensors

- Provide abrasion, condition and movement data



i.Cee ... ... in use at train washing station in Luxembourg ...

Challenge

The previous energy chain systems of a competitor caused disruptions in the operation of the plant, as they were often failing. This was particularly problematic because the washing plant is operated autonomously and a failure of an energy chain system could bring the entire washing process to a halt. The necessary repair measures were therefore time-consuming and partly necessary at night and on weekends. Failure would mean the confinement of a rail vehicle in the wash hall, which could result in the cancellation of several train runs.

The solution with smart plastics

The aim was to find a product that not only safely supplies the washing trolleys with data, voltage, compressed air, water and cleaning agents, but also fulfils CFL's requirement to operate Europe's most modern train washing plant. For this purpose, a system was required that allows the operator to monitor each individual energy chain and to avoid a breakdown of the plant. Besides an igus® energy chain designed for long travels, igus® smart plastics components were installed. Sensors monitor the status of every igus® energy chain during operation with regard to the application of force but also with regard to wear and tear, and inform in good time as soon as a repair or replacement is required. In the course of the modernisation of the energy chain systems, the entire cleaning system was also renewed, so that in addition to particularly environmentally friendly cleaning agents, the used washing water was also reused again and again through reprocessing.

EC.P/EC.W/EC.M

- EC.P sensor measures the tensile forces acting on the e-chain®
- EC.W Sensor measures the e-chain® wear
- EC.M sensor measures all dynamic parameters of the energy supply

... and many other exciting projects

"If the containers stop ..."

A big German crane manufacturer relies on the **i.Sense** online system to ensure optimum production. Here, using "machine learning" and AI algorithms, a calculation of the service life is performed and displayed in a Web dashboard on any Internet-enabled device as a statement of "days until the next recommended maintenance".

Read more about this application at

▶ www.igus.eu/smartplastics

I would be happy to answer your questions.
Richard Habering

... Input options

Motion profile

... Siemens PLC connection

... integrated acceleration sensors EC.W/EC.IM

... OPC UA customer application server

... GPS position data

... igus® positioning system EC.PP

... Standard positioning systems, e.g. 4-20mA

i.Cee:software

i.Cee Module

i.Sense Module

... Output options

i.Cee:output

... Siemens S7

... OPC-UA-Server

... IoT-Cloud-Dashboard

... HTTP Dashboard via private IP address

... MES/SCADA

... JSON-File via MQTT Broker

... REST via HTTP

... Text or .CSV file

... Text messages via SMS

... Sensor raw data management via SMB protocol

... Sensor raw data management via FTP

... FANUC Field System Integration

Anyone who can make reliable and useful predictions about maintenance work is one step ahead of the competition. In the age of digitisation, more than Big Data is required for such predictions. In order to be able to use the sensor data to derive the correct recommendations for maintenance to be accurately scheduled, long term empirical values from the igus® test database are used.

- 3,800m² test area
- 4,100 energy chain system tests annually at 180 test stations: climate chamber, outdoor tests, noise chamber, travel lengths up to 130m, robot systems, etc.
- 2 billion test cycles a year for highly flexible cables
- 1 million electrical measurements recorded annually
- 15,000 tribological tests (friction and wear) in 300 test set-ups
- 140 trillion test movements in the bearings business unit
- Sensors on the test machines provide permanent measurement data, processing in the central database

P4.1 e-chain® with EC.PP in the igus® outdoor test

Switch cabinet with smart plastics modules

Calculate service life online and get a 36-month guarantee!

igus® lab, Cologne. A section of the motion plastics® test laboratory spread over 3,800m²