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WHITEPAPER

SENSORS FOR HARSH ENVIRONMENTS

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IPF ELECTRONIC

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1 INTRODUCTION

When sensors are depicted in applications, they are often seen from their ''best side'', i.e. mostly in a clean environment. However, the reality often looks different, with extreme dust and dirt reflecting only a few environmental conditions that the devices are actually confronted with in tough practical use.

There are several good reasons why the sensor solutions from ipf electronic are nevertheless indestructible and always work safely and reliably despite extreme operating conditions, just a few of which are mentioned here: the selection of particularly robust housing materials, the targeted protection of the sensitive electronics, e.g. through full encapsulation, special design-related measures at the installation location of the sensors, and generally the high-quality workmanship of the overall solution, which was sometimes developed as a special device particularly for the requirements of an application.

This whitepaper offers insights into the rough everyday practice of various industries and shows sensors from ipf electronic as they are encountered in concrete applications after some time in use. The numerous examples impressively demonstrate the extreme environmental conditions that the devices based on different technologies have to withstand and at the same time underline the durability of the robust solutions.

2 INDUCTIVE SENSORS

Inductive sensors are commonly known for their ''taker qualities'', because the devices for non-contact detection of metallic objects are virtually predestined for demanding environments, whether high or low temperatures, high pressures, vibrations, acids, alkalis, oils or metal chips.

2.1 EFFICIENT METAL RECYCLING IN A FOUNDRY

In a foundry, a conveyor belt is filled with recycled material for metal recycling at a collection point. The material is transported via the belt and a discharge chute to a container below the collection point. The container in turn travels on a shuttle to feed the raw materials back into the production processes after melting. The belt is stored on weighing cells, with a PLC controlling the uniform filling of the containers. In the past, however, the weighing belt could only be filled if there was also a container at the discharge chute, as otherwise cast iron could fall onto the path of the transport car during weighing. In order to achieve shorter cycle times in raw material recycling, ipf electronic developed an inductive metal detector coil with integrated evaluation unit for detecting even the smallest parts.

The 950mm wide detector was mounted at a distance of 200mm below the weighing belt, protected from mechanical damage. If the material approaches the discharge chute during weighing, the detector emits a signal that stops further transport over the belt and thus prevents uncontrolled dropping of castings into the chute.

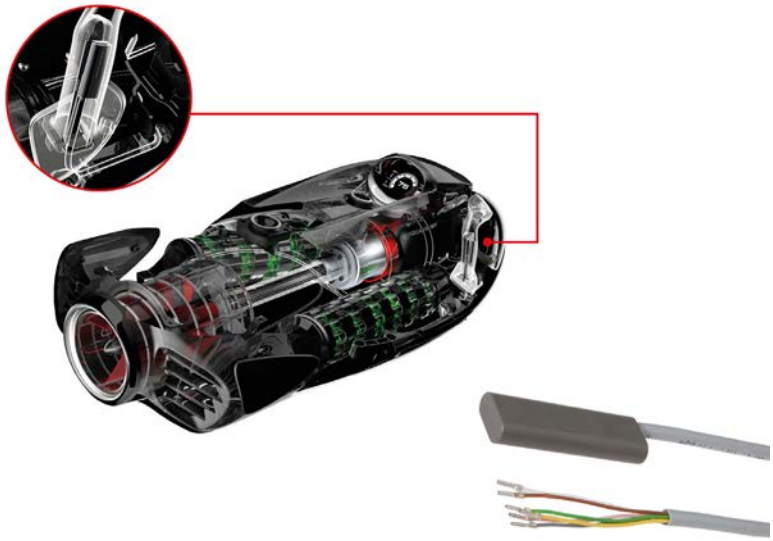
Thanks to this solution, the foundry is now able to fill the weigh belt at the collection point for the recycled material even if there is no container below the discharge chute. The picture of the application gives an impression of the environmental conditions at the place of use of the inductive metal detector coil.

The detector coil works perfectly even if, over time, dirt and metal dust are dirt and metal dust is deposited on it
(All images: ipf electronic gmbh)

2.2 MORE SAFETY WHEN RIDING THE WAVES

The **IN98C973** inductive sensor was developed for use in seawater and for possible water depths of up to 40m, more precisely for a dead man's switch integrated in the grab handles of a water jet. As soon as the operator's hands no longer enclose the handles, this switch deactivates the jet drive.

The solution consists of a double switch in a seawater-resistant housing in which two inductive sensors are installed. In order to achieve a high level of interrogation reliability, the sensor has been designed with internal redundancy and carries out both a normally open contact and a normally closed contact, which switch in opposite directions when actuated. The double switch also contains an NTC resistor, as the customer also wanted a temperature query at the installation location of the solution.



Resistant to aggressive seawater and water depths up to 40m: sensor solution for a dead man's switch in the grab handles of a water jet.

2.3 ALTERNATIVE TO MECHANICAL DIFFUSE-REFLECTION SENSORS

The developers at ipf electronic were faced with completely different challenges at a manufacturer of plastic products. The background: Before injecting plastic, the injection mold must be completely closed. Therefore, mechanical limit switches are usually used to monitor the position of the upper mold, but they are susceptible to wear due to frequent actuation. In addition, high temperatures of sometimes more than +100°C stress the mechanics of the switches. The limit switches installed in the injection molds of the plastics processor therefore no longer provided a clear signal after a certain period of use, so that the injection molding machines stopped repeatedly during production despite the molds being completely closed.

2.3.1 ROBUST ELECTRONICS INSTEAD OF VULNERABLE MECHANICS

With the specially developed **IB98A329** and **IB98A330** inductive sensors for ambient temperatures up to +100°C and +140°C, respectively, the problem was solved. The sensor housings are identical in construction to the previously used mechanical limit switches for easy replacement and also integrate the entire electronics, which are protected from high temperatures and also temperature fluctuations by a special potting.

Electronic alternative to mechanical limit switches in injection molds: The **IB98A330** inductive sensor is designed for ambient temperatures up to +140°C.

The robust **IB98A329** inductive sensors for maximum temperatures of +100°C (left) and **IB98A330** (maximum temperature range up to +140°C) are identical in design to the previous solutions, but far more durable.

2.3.2 EASY INTEGRATION INTO EXISTING TOOLS

In addition to the limit switches described above, so-called multiple limit switches in the injection molds also repeatedly caused problems. The mechanical switches are used, for example, for position sensing of core pulls, which ensure that the injection molded parts are removed from the mold after injection when producing recesses or cutouts. For example, a cam on the core puller actuates a plunger on the probe, which then triggers a mechanical switch for signal transmission to the control system in order to query the retracted and extended core puller position before and after injection.

The alternative solution: the **IC220120** inductive sensor, which is also based on the housing design of existing multiple limit switches. The device has a very small switching distance of up to 2mm, as it has to be positioned very close to the cams. The housing including the active surface made of full metal protect the solution from unintentional contact with the core pull cam, among other things.

The **IC220120** for the standard M12 connection was developed as a robust alternative to multiple limit switches for sensing core pulls in injection molds. The housing, including the active surfaces, is made entirely of stainless steel.

2.4 TEMPERATURE RESISTANT UP TO +230°C

Sensors in a cathodic dip painting system for automotive components have to withstand much higher temperatures than the solutions described above when sensing the position of a lifting device in a curing oven.

Since in this particular case it is not possible to integrate a dripping station in the system between the dip coating and the curing oven, the parts enter the oven directly. Here, the excess paint on the workpieces evaporates abruptly, settles as condensate on the top of the oven and then drips onto the system components. The sensor must therefore be extremely tight and withstand the high temperatures of up to +205° C in the oven.

The solution: a two-part system consisting of an **IN50C543** inductive sensor and a separate evaluation unit. The sensor itself is sealed by the use of special materials and thus prevents the penetration of condensate, which has much higher creep properties than water. In addition, even the high furnace temperatures cannot harm the sensor due to its temperature resistance of up to +230° C. For rapid replacement in the event of mechanical damage to the sensor, the solution is designed as a plug-in system that still maintains a high level of tightness.

The **IN50C543** inductive sensor of the two-part system (**IV400720** amplifier below) for position sensing of a lifting device in a baking oven withstands temperatures up to +230°C.

2.5 PARTICULARLY TIGHT AND EXTREMELY PRESSURE RESISTANT

Sensor solutions for a manufacturer of construction machinery have to be particularly tight and also extremely pressure-resistant. In so-called recyclers and soil stabilizers, a specific gear position is to be sensed with a sensor. Here, the sensor not only comes into contact with fully synthetic oil, but is also exposed to temperatures of up to +120°C. The sensor solution must also be extremely pressure-resistant at the gearbox end.

In addition, the solution at the installation site must seal the gearbox housing and be equipped with a connector from Deutsch. The **IC98C727** inductive sensor, including the active surface, is made of stainless steel and is therefore fully enclosed. The sensor housing is designed in such a way that a sealing ring can be integrated. The solution with customized connector is suitable for operating temperatures of up to +130°C.

The **IC98C727** inductive sensor with connector plug according to customer specifications is installed, for example, in a cold milling machine for recycling asphalt.

2.6 SEEING THROUGH EVEN IN EXTREMELY OILY ENVIRONMENTS

With products such as steel wire for ropes, spring steel wire, chain steel wire or automatic steel wire, the wire industry is an indispensable supplier for many sectors. A company specializing in this area would like to detect the start of each product during the production of round steel on a cut-to-length machine with feed automation in order to be able to cut it off in predefined lengths. For this purpose, a sensor solution was sought that would always work reliably even when using a lot of oil for forging the cutting tools in the immediate production environment. ipf electronic recommended the **IY500320** inductive ring sensor as the solution, since the device is characterized by high resolution, adjustable sensitivity, chemical resistance to the oil and tightness, among other features, and is therefore ideally suited for the specific requirements in this application. In addition, the ring sensor is extremely insensitive to contamination, whereby even oil in strong form does not impair the functioning of the device.

Ring sensors from ipf electronic are ideally suited for use in machine and plant engineering and are increasingly used in the fields of assembly technology and feed automation. The solutions are divided into static and dynamic ring sensors. Static ring sensors offer optimum functions for all conceivable areas of application, e.g. for the detection and jam control of small metal parts in feed hoses. Dynamic ring sensors are mainly used for the detection of fast moving objects. They have a high resolution and detect even the smallest parts with low mass.

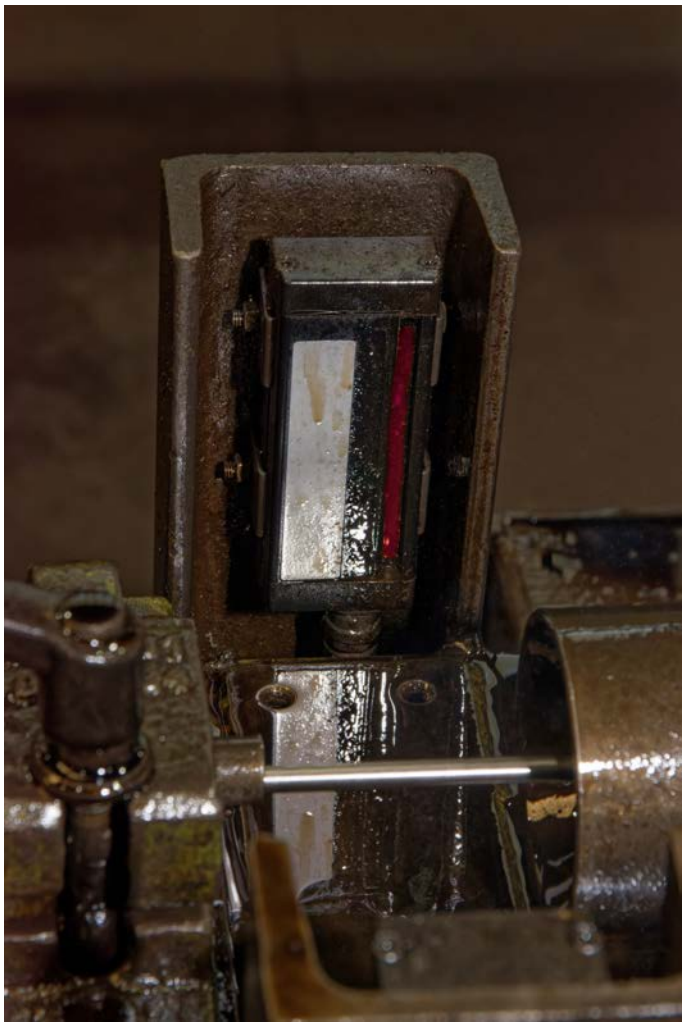
The **IY500320** inductive ring sensor always works reliably even in extremely oily environments and reliably detects the round steel at the cut-to-length machine.

3 OPTICAL SENSORS

Optical or optoelectronic sensors convert optical information into electrically evaluable signals and primarily use visible light, infrared light or ultraviolet light for this purpose. The selection of optical sensors from ipf electronic is very broad, with one-way systems, reflection systems and sensing systems being offered. Due to the wide range of solutions, optical sensors are very versatile and prove their strengths especially in environments with very demanding and rough conditions.

3.1 LIGHT GRID DETECTS STEEL WIRE UNDER HARSH OPERATING CONDITIONS

Chapter 2.6 described the use of a ring sensor for the detection of round steel on a cutting machine. The same company has a similar application in another production area, where bar material is also to be cut to predefined lengths. However, since the steel wire here has a relatively small diameter, it can deflect in one direction when the end of the material is reached. If a ring sensor were used to detect the bar material, there would therefore be a risk of damaging the inner ring of the device as the active sensor surface.
For this reason, an optical sensor, more specifically a light curtain **OY410522**, was used in this application to detect the steel wire. To protect it from any damage, the light grid was inserted into a U-steel. As in the application described above, a lot of oil is used to lubricate the cutting tools, which means that the light grid is also exposed to a lot of dirt. Nevertheless, the solution works perfectly.



A light curtain **OY410522** protected in a U-steel for the detection of steel wire.

The solutions of the **OY41052x** series in aluminum housing (protection class IP65) belong to the so-called multifunctional light curtains from ipf electronic. The devices, which operate with infrared light, are available with field heights from 75mm to 2,010mm, are suitable for a temperature range from -5°C to +50°C and are very versatile due to their variable range (up to 8m). The application described here also proves that the light curtains can master even the harshest environmental conditions.

3.2 ONE-WAY BARRIERS RESIST SULFURIC ACID

The engineers at ipf electronic faced even greater challenges at a company that needed sensors that could withstand the most extreme conditions for the automated material handling of copper sheets in a continuous pickling line. The pickling line was designed to remove the oxide layer that forms on the surface of copper sheets during rolling before the sheets are further processed with sulfuric acid solution.

3.2.1 AUTOMATED MATERIAL HANDLING FOR CONTINUOUS PICKLING

After rolling, the plates, some of which have a temperature of up to +500° C, are transported via a roller table to a straightening machine which removes the surface waviness. This machine is followed by a device with which the individual sheets are lifted from a roller table and then positioned correctly aligned in two buffer zones in front of the pickling chamber. After a sheet has been treated on both sides in the pickling chamber, it is conveyed to one of three other buffers that serve as intermediate storage. If no sheet comes out of the roller, a finished pickled sheet can be removed from this intermediate store via a roller table for further processing. For the two buffer zones before pickling, for the pickling chamber itself, and for the three downstream material buffers, the company required precise sensor solutions that work reliably under the toughest environmental conditions to ensure safe automated handling of the sheets in the plant.

3.2.2 PRECISE, ROBUST LASER LIGHT BARRIER WITH HIGH RANGE

The solution for the two buffer zones directly behind each other in front of the pickling chamber had to reliably detect the front position of a sometimes curved sheet (material thickness 8 to 160mm) and in doing so scan the entire area just above the roller table over the entire material width of up to 6 meters. The sensors therefore had to have an exact, small measuring point with a long range and at the same time be extremely robust, since the pickle consists of a solution with 15 to 20 percent sulfuric acid and therefore massively affects the devices.

ipf electronic therefore recommended a laser light barrier consisting of a **PS180024** transmitter and **PE180424** receiver in a metal housing (protection class IP67). The disposable system has a large switching distance of max. 60m and could be adjusted very well due to the visible laser light in the area above the roller conveyor. The very small and therefore precise light spot makes it possible to reliably detect the front position of the thin sheets in the two buffer zones in front of the pickling chamber over the entire width of the material.

The sensors are connected to the PLC of the plant and signal to the control system that a sheet is in the respective buffer zone. Once the treatment of a sheet with acid solution has been completed and the sheet has left the pickling chamber, the sheet located in the zone upstream of the pickling chamber can be transported into the chamber. The buffer zones downstream of the surface treatment are also equipped with the **PS180024/ PE180424** laser light barriers and report to the PLC when the buffers are completely occupied in order to avoid material jams. In the pickling chamber, the metal sheets are sprayed with pickle from above and below on roller tables in reversing operation. Here, too, the position of the sheet must be scanned in conjunction with the sensors in the buffer zones. For this purpose, ipf electronic's **IO300106** inductive sensors with an active surface made of stainless steel are used. Among other things, these sensors are designed for ambient temperatures up to +70°C and have IP68 protection.

Hardly recognizable: The acidic pickling process is extremely the laser light barriers in the buffer zones.

3.3 OPTICAL DIFFUSE-REFLECTION SENSORS FOR DUCTILE IRON COOLING SECTION

In the following application, the optical sensors are exposed to high temperatures and immensely high dust levels in a foundry that produces so-called nodular cast iron parts for commercial vehicles. The nodular cast iron is cast in special containers filled with sand. After filling, the sand is compacted to obtain a negative mold. After casting and cooling, the casting is removed, the sand is recycled and the container is filled with sand again for the next casting. To cool the nodular iron castings, a cooling section is used in which the containers are transported and positioned in a rotary motion on various chain-driven roller conveyors. A particularly robust and reliable sensor system was needed to monitor the positions of the cast containers and to coordinate their transport on the six tracks of the cooling line.

3.3.1 PROBLEMS WITH RANGE AND REFLECTIONS

The devices are not only exposed to high temperatures on the cooling line, but also to extreme dirt and dust loads. The inductive proximity switches previously used could no longer be used after the container station was rebuilt because their range was too short. The new solutions had to have a scanning range of around 20 centimeters to detect the containers. The optical sensors used as an alternative had difficulties in detecting the cast containers due to their partially reflective side walls.

Inductive sensors and conventional optical scanners repeatedly led to problems in the container station.

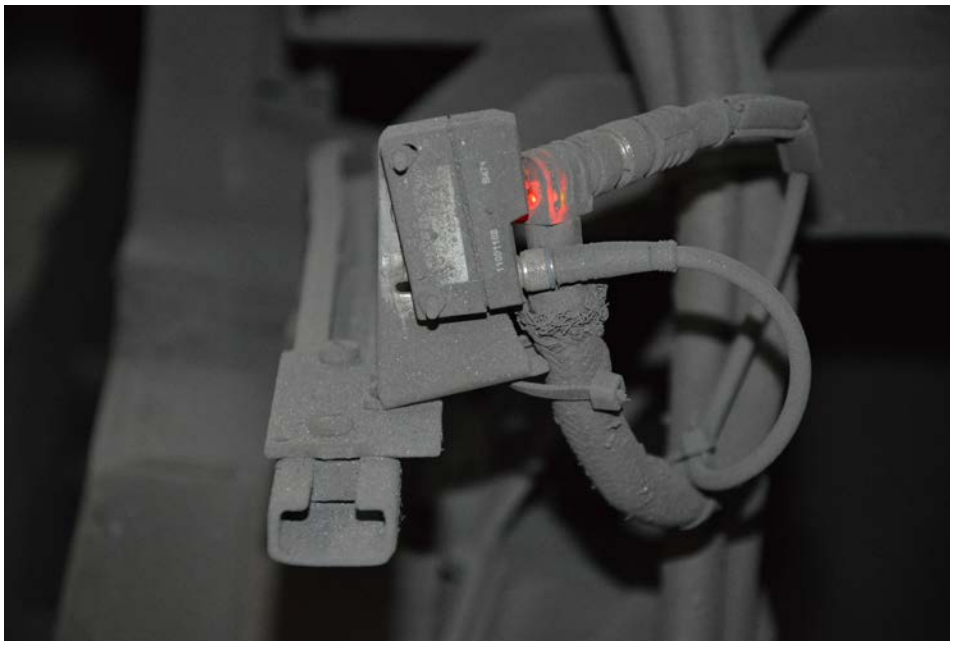
3.3.2 SOLUTION WITH CLOCKED RED LIGHT AND CONVINCING PROPERTIES

The previous sensors in the container station were therefore replaced by the **OT430423** optical sensors from ipf electronic. The devices, which operate with pulsed red light and come in a robust plastic housing, are very compact (sensor integrates transmitter and receiver), are suitable for use in a temperature range of -25°C to +65°C, and have impressive scanning distances of 30 to 500mm. The sensors are also capable of detecting materials in the sensing range regardless of their reflectance, which applies to both the color and the surface of the object to be detected. This is because the receiver elements of the optical scanners evaluate the object position from which the incident transmitted light is reflected. This makes it possible to determine whether an object is located in the selected detection or switching range, provided that the object surface, in this case the side walls of the cast containers, reflect the incident transmitted light to a sufficient extent. The effective scanning range of the **OT430423** is therefore not dependent on the object to be detected, but exclusively on the previously set scanning distance.

Typical operating conditions in a foundry. Higher temperatures and above all dust characterize the production environment.

3.3.3 COMPLETELY INSENSITIVE TO EXTREME POLLUTION

In the meantime, all old devices in the cooling section have been replaced by the optical sensors of the **OT43** series from ipf electronic. In practical use, the sensors have proven to be particularly insensitive to dirt, as the present image material illustrates. Another advantage is the comparatively large scanning range required for reliable detection of the cast containers. Moreover, the solutions are ideally suited for the detection of differently reflecting materials. This is another plus point for this application, because the cast containers have different reflective properties. With previous sensor solutions, the foundry repeatedly had problems with such reflections, especially when new containers were fed into the system. Problems that are now finally a thing of the past.



The **OT430423** optical scanners detect materials regardless of their reflective properties and are insensitive to high dirt loads.

3.4 HIGHLY EFFICIENT DUE TO INFRARED LIGHT AND HIGH TRANSMISSION POWER

High-performance light barriers are one of the disposable systems among optical sensors and consist of a transmitter, receiver and amplifier (single-channel or multiplex amplifier). Depending on the combination of the individual components, such systems can achieve total ranges of up to 70 meters. The power reserves available due to the high transmission power of the photoelectric sensors are used primarily for highly efficient contamination compensation over shorter distances. The systems use infrared light as the transmit signal, which has particularly good penetration properties due to its wavelength of around 880nm. A few selected examples show the advantages from which practical applications can benefit in this context.

3.4.1 HIGH RESPONSE SENSITIVITY AND CONTAMINATION COMPENSATION

A classic example for the use of high-performance light barriers are car wash systems or so-called portal car wash systems. In particular, the main cleaning brushes and drying fans of such systems, which travel over the vehicle body during cleaning and drying, require a sensitive photoelectric sensor that is also capable of detecting vehicle glass (e.g. front and rear windows) in order to regulate the corresponding pressure of the brushes and the distance of the drying fan in accordance with the vehicle contours. In such systems, the optics of the high-performance light barriers are exposed above all to contamination from the wash water and impurities detached from the vehicle. Added to this are, for example, cleaning agents and foam, and possibly also water containing lime, so that lime residues can also be deposited on the optics.

Wetness, dirt and cleaning agents are just a few of the conditions to which high-performance light barriers in car washes are exposed to.

As already mentioned, light barriers with high response sensitivity are required in car washes that can simultaneously compensate for the soiling to which the optics of the transmitter and receiver are exposed. However, a light barrier with a fixed setting of the transmitter power is not able to cope with these basically opposite requirements. Therefore, solutions with single-channel amplifiers have been developed that allow an automatic mode of operation. They offer high response sensitivity due to the reduction of the transmit power to a safe minimum level and can also automatically readjust the transmit power as the optics become increasingly dirty. A further advantage is that such a system solution can output a signal before the connection amplifiers reach their control limits due to soiling of the optics of the high-power photoelectric sensor. This means that the transmitter and receiver can always be cleaned in good time or on schedule.

3.4.2 SAFE ATTENDANCE CONTROL THROUGH A CONVEYOR BELT

High-performance light barriers can do much more, however, as the following application shows. In a plastics processing plant, the presence of flat, large-format plastic parts on a conveyor belt for transfer to a subsequent transport process has to be monitored after a furnace cycle. The ambient temperatures in the query area are higher because the plastic parts are still warm, and there is a high level of dust generation due to the process. The presence of the plastic parts must be detected by the conveyor belt, which consists of a rod mesh- and as far as possible without false signals.

The presence check of plastic parts must be carried out by a conveyor belt made of rod mesh.

For this purpose, ipf electronic's solution consists of a transmitter with a beam angle of 6 degrees for maximum transmission power with a long range, a receiver (beam angle 25 degrees) and a single-channel amplifier with an additional analog output for precise adjustment of the transmitter and receiver, with the degree of alignment being displayed via a 0-10V signal.

Because light barriers can achieve long ranges, the transmitter and receiver could be mounted in an outer, thermally uncritical area of the conveyor belt. In contrast to initially unsuccessful attempts with other solutions such as a retro-reflective sensor and a laser scanner, this system enables reliable and continuous presence monitoring of the plastic parts.

There is a high level of dust generation combined with high temperatures at the high temperatures. Due to the long range, the light barriers (here the transmitter) could be installed in a thermally uncritical area.

3.4.3 COMPENSATION FOR WEATHER INFLUENCES

On the subject of high-performance light barriers, here are two more applications that underline the performance of such solutions. The next illustration shows the use of high-performance light barriers with a 2-channel multiplex amplifier at a gate entrance. This application once again demonstrates the versatility of such systems, which can compensate not only for contamination but also for weather conditions such as fog, icing or snow.

High-performance light barriers at a door entrance. The system works perfectly even even when snow on the ground protrudes into the lower infrared beam, because the specified transmission power is automatically readjusted.

3.4.4 LIGHT CURTAINS FOR APPLICATION-SPECIFIC USES

The portfolio of high-performance light barriers from ipf electronic also includes multiplex amplifiers for the connection of 4- or 8-transmitter/receiver systems. With such solutions, light grid functions can be activated. If this function is selected, a single switching output is activated when any light beam is interrupted. For a flexible light grid height, several amplifiers can be coupled together to integrate additional light barriers into the light grid.

Such light grids are used in sawmills, for example, to reliably detect the start of tree trunks on conveyor systems, e.g. in front of band saws. The systems are also exposed to high levels of dust and dirt, among other things from the fine sawdust. The figure below shows that very application-specific solutions with flexible light grid heights can be realized through light grid operation, whereby the individual high-performance light barriers do not influence each other during operation.

Light curtain on a conveyor belt for logs in front of a band saw. The coupling of several multiplex amplifiers enables solutions with flexible light grid height.

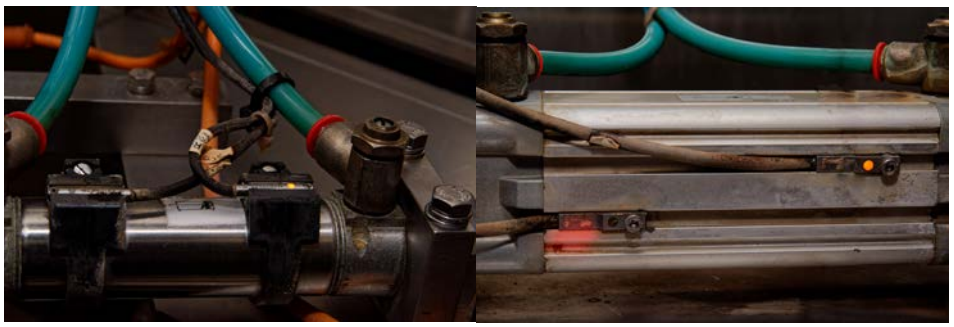
4 MAGNETIC CYLINDER SENSORS

Cylinder sensors belong to the group of magnetic field sensors and are used for sensing the piston rod position in pneumatic cylinders. The cylinder sensors from ipf electronic are characterized by an extremely robust design, as many devices have a housing made entirely of metal. In practice, magnetic cylinder sensors have to withstand, among other things, high mechanical loads such as shocks, vibrations, extreme oscillations, etc.. In addition, they are sometimes exposed to very low or very high temperatures and frequently come into direct contact with coolants and lubricants, emulsions, oils and also cleaning agents as well as solvents. The durable solutions can therefore withstand very different harsh operating conditions. The following application examples provide a small sample.

4.1 EXTREMELY DURABLE DESPITE MANY CLEANING CYCLES

A contract bottler supplies wine to retail chains worldwide. Among other things, various wines are filled in so-called bag-in-boxes. A bag-in-box is a high-quality disposable packaging consisting of a handy transport carton containing a foil bag for liquid media with an integrated tap. In a filling system for the bag-in-boxes, the piston rod position must be sensed by various pneumatic cylinders, firstly when transporting the film pouches into the filling station and secondly when positioning the film pouches so that their filling spouts are precisely aligned with the filling valve of the station. In the past, common plastic cylinder sensors were used for the pneumatic cylinders. However, these devices did not prove to have a particularly long service life, because due to the high hygiene requirements, the station is cleaned twice a day with a cleaning agent containing alcohol. After some time, this caused the plastic of the sensors to become brittle, the housings to swell and the devices to eventually leak. For this reason, the sensors had to be replaced regularly, at least twice a year.

An application specialist from ipf electronic recommended the **MZR401A9** and **MZ0701A8** cylinder sensors to the bottler instead. The compact **MZR401A9** with IP67 protection for installation in a C-slot is particularly suitable for use in harsh environmental conditions thanks to its stainless steel housing. The **MZ0701A8** (IP67), on the other hand, can be easily inserted from above into a 6.2mm T-slot of pneumatic cylinders thanks to its housing design. This sensor also proves to be particularly robust due to its V4A housing, among other things. The **MZR401A9** was installed on the pneumatic cylinder for transporting the film bags to the filling station, while the **MZ0701A8** cylinder sensors scan the piston rod position on the pneumatic cylinder for aligning or centering the film bags. All cylinder sensors from ipf electronic have already been in operation in the filling line for more than two years and are still working perfectly.

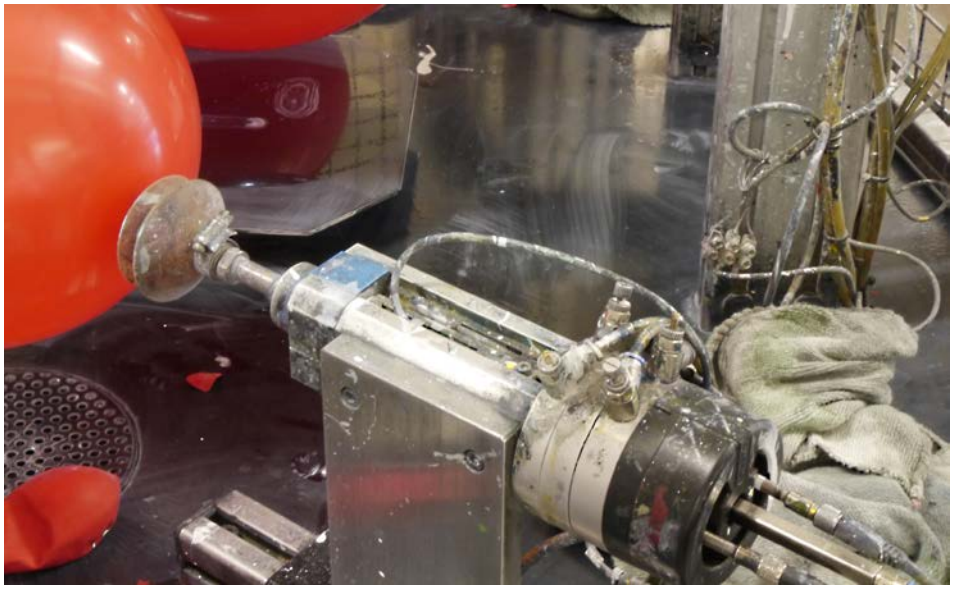


Robust and extremely durable: The **MZR401A9** (top) and **MZ0701A8** cylinder sensors in metal housings replace conventional devices made of plastic in a filling line, as these were not able to withstand the frequent cleaning cycles with an alcohol-based cleaning agent and therefore had to be replaced more frequently.

4.2 RELIABLE EVEN WITH PAINT AND SOLVENT

Cylinder sensors from ipf electronic are exposed to color deposits as well as highly effective cleaning agents and solvents in a company for advertising materials. Among other things, the company provides balloons with single- and multi-color imprints according to customer requirements. For printing on both sides with the desired motif, the balloons are inflated in a system to a part of their actual volume. In the printing station, a motif is first applied to one side of the balloon, which is then turned on a turning device to apply the motif to the second side of the balloon as well.

To do this, a vacuum suction head is moved up to the balloon in the turning station via a pneumatic cylinder. The head first sucks in the balloon, then moves back over the pneumatic cylinder, rotates through 180 degrees, then moves forward over the cylinder and places the balloon back on the holder. Since a balloon can also burst once during the turning process, ink splashes in the system and thus ink deposits on the cylinder sensors are not uncommon. Nevertheless, the devices work flawlessly and reliably throughout the entire production process. Since the system is also cleaned regularly to remove paint residues from profiles and other system components, for example, the cylinder sensors come into direct contact with highly effective cleaning agents and solvents. However, the sensors in the metal housing (protection class IP67) survive even this ''treatment'' completely unscathed.

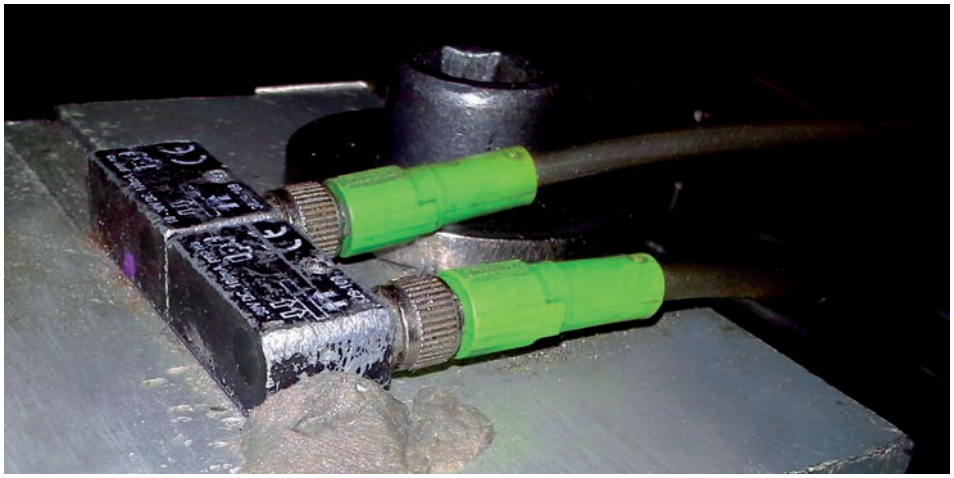


The cylinder sensors in the system for printing balloons are exposed to paint splashes and highly effective cleaning agents and solvents.

With the magnetic cylinder sensors from ipf electronic, this company has also found solutions for a production environment that places special demands on high reliability and thus wear-free as well as trouble-free operation of the devices in several respects. However, cylinder sensors have to withstand much higher loads in the subsequent application.

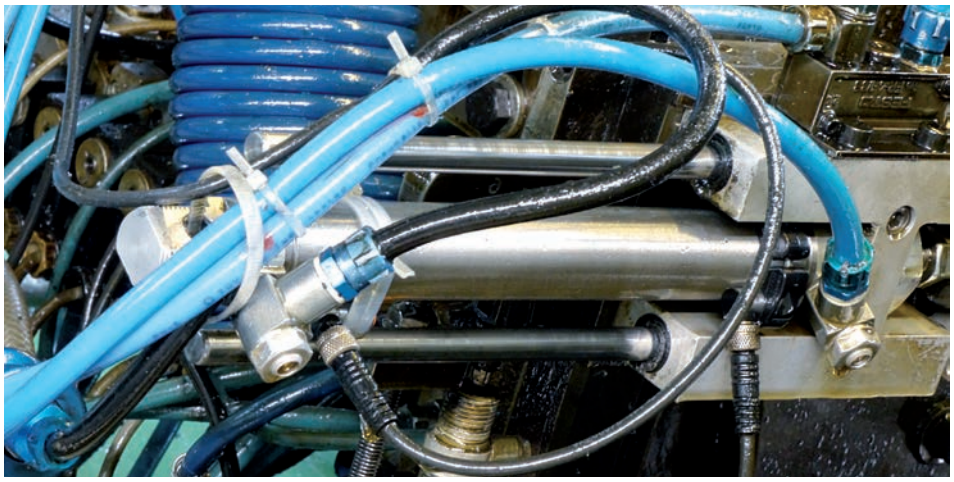
4.3 EXTREMELY ROBUST UNDER HIGH MECHANICAL LOADS AND TEMPERATURES

A manufacturer of clamping systems for the metalworking industry uses a die changing system with self-developed hydraulic cylinders on a press in its production. During a die change, the cylinders are extended to firmly fix the press die. The special hydraulic cylinders have a housing made of non-magnetic stainless steel. In addition, the piston rod is equipped with a ring magnet, which can be detected on the cylinder from the outside with a magnetic cylinder sensor. The special challenges for the sensor solution from ipf electronic: very high temperatures at the sensing point, since the oil used in such hydraulic systems can absorb temperature and become hot. In addition, there are extremely harsh operating conditions with extraordinarily high mechanical loads. With the **MZA70155**, ipf electronic has developed a cylinder sensor in a metal housing especially for this application, which is designed for the extreme conditions and thus also for high temperatures of up to +100°C. The sensor is also able to withstand the high mechanical loads. The sensor also withstands the high mechanical stresses. A grub screw integrated in the sensor housing also ensures that the device is securely fastened despite constant shocks, jolts and vibrations.



High temperatures up to +100°C and extraordinarily high mechanical **MZA70155** cylinder sensors are exposed to high temperatures up to +100°C and extremely high mechanical loads.

In the application described, it is the high temperatures, among other things, that challenge the cylinder sensors through the use of hydraulic oil. In the following illustration from another operation, however, it is the oil itself that the cylinder sensors from ipf electronic have to withstand.



Cylinder sensors on a machine in an extremely oily environment.

5 CAPACITIVE SENSORS

One of the main intentions for the development of capacitive sensors was basically to obtain device solutions that can be handled in applications similar to inductive sensors, but are also able to detect non-metallic materials and liquid media without contact. Capacitive sensors are wear-free, do not require maintenance and have a service life that is independent of the switching frequency. Practical experience has shown time and again that capacitive sensors can overcome challenges, e.g. in the level control of very difficult media, where other sensor technologies usually fail. Here are two application examples.

5.1 LEVEL MONITORING OF VISCOUS LUBRICANT

In a metalworking company, specific vehicle parts are manufactured on an automated punching press. One component of the punching tool must be permanently lubricated during the production process. For this reason, the viscous lubricant is to be metered from a reservoir and fed via a pump to the relevant points on the tool. The fill level of the reservoir must be checked continuously in order to ensure reliable automated production. However, due to the consistency of the lubricant, all the sensors previously used for this purpose were unable to ensure reliable level control. A non-contact measurement of the level from above using an ultrasonic probe was also out of the question, since the device did not provide reproducible results due to the rising warm oil vapors (convection).
At the request of the company, ipf electronic therefore recommended the **FK920420** capacitive level sensor for this task.

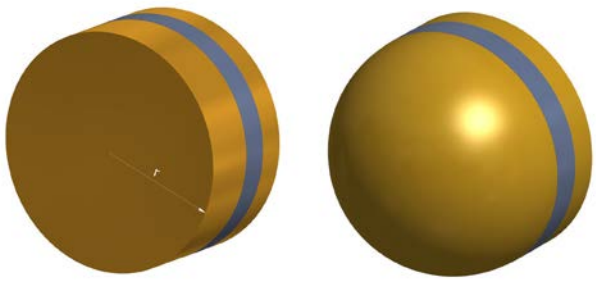
FK920420 capacitive level sensors in a storage tank for permanent lubrication of a punching tool.

The design of the sensor in piston form with a Teflon housing is striking. The design is such that the sensor can project vertically from above into a container and thus into the medium to be monitored. In the context of the application described here, the special design is fundamental, not only with regard to the dripping behavior, but also with regard to the size of the active sensor area and thus the capacity of the **FK920420** compared to conventional devices.

The FK920420 is a special solution with a piston-shaped Teflon housing.

5.1.1 LARGER ACTIVE AREA DUE TO PISTON SHAPE

The size of the active area of a capacitive sensor can be calculated according to the following formula: A = r^2 x 3.14, where r is the radius of the active area. The size of the active area of a device in size M30 for non-flush mounting is therefore 490.6mm². Due to the piston-shaped design of the **FK920420**, the active area located in the shaft of the sensor can be designed differently. Therefore, the formula for hemispherical surfaces applies for its size calculation: A = 2 r^2 x 3.14. With a diameter of only 26mm, the **FK920420** has an active area of 904mm², which is almost twice as large as the active area of a conventional sensor in size M30 (non-flush).



Comparison of the size differences of the active area of a classical electrode (left) and a hemispherical electrode (right).

The capacitance of a sensor such as the **FK920420** correlates, among other things, with the size of its active area. The larger this area, the greater the capacitance of the sensor and thus also its response sensitivity and its possible adjustment range.

5.1.2 HIGH CAPACITY AND EXACT ADJUSTMENT ELIMINATES INTERFERING INFLUENCES

For the application described, the design of the **FK920420** therefore offers various advantages with regard to reliable level control. If the level of the lubricant in the container drops below the measuring probe, for example, the medium can drain off the sensor easily due to the shape of the piston. Possible droplet residues of the lubricant film on the sensor cap do not influence the measurement. Residues of the viscous lubricant, however, which also form on the sensor cap and therefore in the area of the electrical field, can be specifically suppressed due to the high capacitance of the device by an exact adjustment of the required response sensitivity. In the following application, it is mainly aggressive media and harsh ambient conditions that make level control a difficult task, but one that can also be mastered by a capacitive sensor.

5.2 LEVEL CONTROL IN AUTOMATED LIME MILK PREPARATION

A company specializing in steel products treats, among other things, stainless steel wire in its inhouse pickling plant. The wastewater from the pickling process is neutralized in a special system and must have a high pH value. This is achieved by adding milk of lime, which the company produces itself by mixing the lime supplied in powder form with water in a tank. Since the milk of lime is prepared fully automatically, the tank must have a level control system that is connected to the plant control system (PLC). However, the float switches used for this purpose in the past did not withstand the harsh operating conditions in the long term. For example, heavy lime deposits repeatedly formed on the float switches, causing the devices to jam. The company's maintenance department therefore had to open the lime milk treatment tank regularly to clean the switches. Sometimes it was even necessary to pump the tank empty for the necessary work, which meant that production had to be interrupted. In addition, the cables of the float switches to the PLC were also attacked and decomposed.

5.2.1 CHEMICAL-RESISTANT SENSOR FOR AGGRESSIVE ENVIRONMENT

With the **FK92E117** level sensor, ipf electronic was finally able to offer a solution that stood up to the aggressive ambient conditions and, in combination with the **BA960900** digital transmitter for signal conditioning, could be easily integrated into the automated lime milk treatment system. The housing of the capacitive sensor with M12-connection is made of stainless steel, the active zone (probe) of PTFE. The **FK92E117** with integrated evaluation electronics is extremely resistant to chemicals, and the actual probe (in this application with a length of 1,100mm) can be used in an ambient temperature range of -25°C to +100°C. The sensor can be used in a wide variety of applications. The device provides an analog current output 4...20mA as well as two programmable switching points.

In the container, the lime is mixed with water to form milk of lime. To the left of the mixer is the PTFE rod probe, on which only a small amount of lime deposits even after prolonged operation.

5.2.2 SYSTEM SOLUTION TAKES OVER SEVERAL TASKS

The **BA960900** digital transmitter processes the preset current signals of the level sensor for the maximum and minimum filling levels and, when these values are reached, sends the corresponding signals via its relay outputs to the lime milk preparation PLC. Up to four freely programmable relay switching points can be assigned to the input signal of the level sensor at the transmitter. If, for example, the lime milk treatment tank has reached its minimum level, the automatic addition of new lime milk is initiated via a switching signal to the PLC. The sensor also monitors the addition of the correct amount of water. In addition, the sensor controls the maximum filling level of the milk of lime as overflow protection and functions as dry-running protection for the pumps located in the milk of lime preparation tank.

The housing and the connection of the capacitive level sensor are made of stainless steel. The limescale deposits are also clearly visible on the container of the preparation unit.

6 SUMMARY AND CONCLUSION

Extremely high or low temperatures, dust, dirt, high pressures, high mechanical loads, aggressive media such as acids, alkalis and chemicals, humidity, moisture and other adverse environmental influences- these are just some of the challenges faced by sensors in tough industrial applications. The spectrum of potential solutions for different areas of application with high demands on availability and thus durability even under the most difficult conditions is extremely broad, as this white paper shows with practical examples. It becomes clear that not only the robust design of a device is important in this context, but also the optimal integration of the overall solution into a specific application. ipf electronic offers a variety of sensors with different technologies and special characteristics, some of which have been developed as special designs for very customer-specific requirements and most of which have been included in the general solution portfolio. Sensor solutions for harsh environmental conditions are to a certain extent a special field in which the application specialists at ipf electronic have gained a lot of fundamental experience over decades. This experience forms the basis for valuable know-how that is available at ipf electronic as expert knowledge at any time for other applications with high demands on sensor technology.

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