Using exhaust gas heat intelligently

Industrial sensor solutions monitor pressure and temperature

Annealing furnaces for strip steel coils generate very high temperatures. The cleaned and low-CO2 exhaust gases from newer systems are therefore ideal for use in a system for heat recovery. The Hagen-based steel company "Bandstahl Schulte & Co. GmbH" had exactly these thoughts in mind with regard to the investment in a hydrogen bell-type annealing furnace. Sensor solutions from ipf electronic played a decisive role in all phases of the project.

"The low consumption of gas as well as the – compared to the old system – faster annealing process in combination with hydrogen as a fuel make our new system very efficient, economical and, moreover, environmentally friendly. To keep the exhaust gases from being directed unused to the outside and, thus, to avoid wasting energy, the idea arose to direct the very warm exhaust gases from the annealing furnace through a heat exchanger to support our heating system with approximately 1 MW of power," explains Marcel Brücher, company electrician from Bandstahl Schulte (Fig. 1).

No interference with the annealing process

For the realization of the project, the entire piping system of the annealing system, among other things, was adapted. Now located directly behind the bell-type annealing furnace is the heat exchanger, whereby the original exhaust pipe serves as a bypass. Next to the already existing fresh-air intake and the hall outlet, an exterior outlet was installed with a fan which can be regulated if necessary (Fig. 2).

One special challenge was that the planned system for heat recovery must not interfere with the processes in the annealing system in any way. "To be avoided at all costs was excess pressure in the heat chamber of the annealing furnace, since a flawless annealing process is only possible at a permanent pressure of -0.2 to 0.6 bar," emphasizes the company electrician.

Extremely temperature-resistant pressure sensor wanted

To master these and other requirements of the project, measured values were to be collected both before and during start up as well as for monitoring and controlling the complete system during later operation. One problem in this context was caused above all by the high temperatures of the exhaust gases. "We therefore needed, among other things, a pressure sensor for monitoring the negative pressure in the piping system directly behind the heat exchanger that could withstand the highest possible temperatures. After extensive research, we found such a solution with ipf electronic in the form of a system consisting of pressure sensor and flange isolating diaphragm," says Marcel Brücher.

Effective decoupling via isolating diaphragm

While the pressure sensor is suitable for ambient temperatures to +80°C, the complete system, consisting of evaluation unit and isolating diaphragm (DW98C986) (Fig. 3), is designed for temperatures of up to +200°C. The isolating diaphragm prevents the high exhaust gas temperatures in the pipe from damaging or destroying the sensor. For this purpose, the process pressure of the exhaust gases is transferred via a membrane in the flange to a fluid, in this case silicone oil, which triggers the measurement element of the pressure sensor via a cable. The isolating diaphragm flange was integrated in the piping system directly behind the heat exchanger and is connected to the pressure sensor, which is located outside of the temperature-critical area, via an approximately five-meter-long cable.

Signal for controlling fan and flaps

The pressure sensor features a measuring range from -1 to +10 bar and has two outputs: one pure switching output and another freely programmable output. As a result, one can choose between analog output (4...20mA), switching output and alarm output (Fig. 4). "We will use the analog output signal to regulate the speed of the fan at the exterior outlet as well as the positions of the flaps in the piping system via the PLC of the system. We use the switching output optionally to, e.g., switch off the fan above a certain negative pressure," explains Marcel Brücher.

More possibilities through optical interface

In the opinion of the company electrician, the additional optical interface of the pressure sensor offers a special advantage, as it can be used to connect a laptop to set, change and check all parameters. "The graphical interface of the corresponding software is easy to use, and pressure peaks lasting longer than just 2ms are reliably recorded and displayed," stresses Marcel Brücher. In addition, it is possible to write the measured values to an Excel-compatible CSV file for performing evaluations or long-term measurements. "As a result, we are able to examine the operating efficiency of the complete system at any time and, if necessary, can take measures to improve the efficiency. Because we are currently still gaining experience with our new heat recovery system, this function is immensely important to us."

Reading of temperature values made easy

The upper temperature limit of the isolating diaphragm of +200°C must be monitored constantly in order to be able to control the regulation of fresh air intake or to completely close or open the corresponding flap of the piping system if necessary. This check is performed by a combination of temperature indicator and PT100 probe (Fig. 5), also from ipf electronic, whereby the measuring probe is installed directly next to the isolating diaphragm (Fig. 6).

Going into greater detail, Marcel Brücher says: "In the entire piping system, we use a total of four indicator devices, including measuring probes. Two measuring probes are located in the exhaust gas system to, on the one hand, monitor the temperature of the DW98C986 and, on the other hand,

monitor the fan, which may be exposed to a maximum airflow temperature of +250°C. Two other measuring probes are used to monitor the supply and return temperature of the heat exchanger." All of the probes are connected to the temperature indicators via sensor-actuator cables. As a result, these devices, which can withstand a maximum ambient temperature of +80°C, could likewise be installed outside of the zones with very high temperatures. Moreover, they are all mounted at one position so that the values of the system can be clearly ascertained (Fig. 7). "Thanks to the identical housing, the optical interface mentioned earlier in the context of the pressure sensor also functions with these temperature indicators. As a result, we can record not only the pressure, but also the temperatures in the piping system. This allowed us to also record various cycles for evaluation purposes before starting up the system." Should it ever be necessary to replace a device, the configuration previously stored on a laptop can be transferred to the new device via the optical interface without great expense and loss of time.

Little energy – big impact

The warm exhaust gases of the old annealing furnace, which were cleaned through multiple combustion processes, were directed to the fresh air outlet without any further use. With the new hydrogen bell-type annealing system (Fig. 8), Bandstahl Schulte now uses the resulting exhaust gas heat very efficiently. "It is true that we do not yet have exact data on the possible savings. After a test phase, however, our initial findings show that we can recover a great deal of heat from the exhaust gas using very little energy and that the project should, as a result, pay for itself very quickly." The sensors and indicator devices from ipf electronic are, in this context, a decisive part of the system. Not only because they provided very important measured values for the start up of the heat recovery system. "The permanent monitoring of the exhaust gas temperature prevents the destruction of mechanical components. In addition, the DW98C986 monitors the total pressure of the system so that - taken together - we have very reliable sensor solutions for monitoring and controlling the system," summarizes Marcel Brücher.

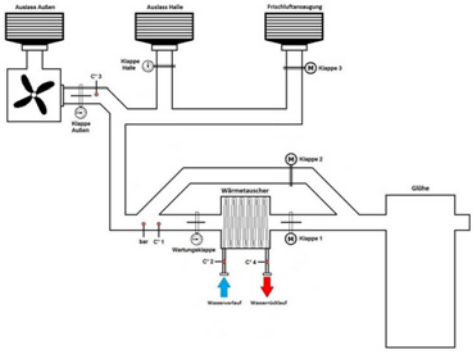
PLACE IN BOXES:

Bandstahl Schulte & Co. GmbH, based in Hagen, is a cold-rolling mill that can look back on more than 50 years of history. The cold-rolling mill manufactures and processes strip steel in any desired variant with approximately 130 employees. The product range includes, among others, hot-rolled steel strips, e.g., as hot slit strips, hot strips with mill edges or in coils or in cut lengths as well as cold-rolled strips (thin sheets), e.g., in coils, as slit strips, in coils or cut lengths, which can also be surface-finished or specially treated on request.

Image captions:

ipf electronic_Bandstahl-Schulte_01:
The very warm exhaust gases produced by the hydrogen bell-type annealing system are directed through a heat exchanger to support the company's heating system.

ipf electronic_Bandstahl-Schulte_02:
The entire piping system of the annealing system was adapted for the purpose of heat recovery. Located behind the heat exchanger is the isolating diaphragm (bar), which is connected to the pressure sensor. A YT036020 probe (C° 1) was installed next to the pressure sensor. The YT353120 temperature indicator is located outside of the temperature-critical zone. Additional PT100 probes are used to monitor the fan (C° 3) and to monitor the supply and return temperature of the heat exchanger (C° 2, C° 4).



ipf electronic_Bandstahl-Schulte_03:

The DW98C986 consists of a flange isolating diaphragm and a pressure sensor. The complete system is designed for temperatures of up to +200°C.

ipf electronic_Bandstahl-Schulte_04:

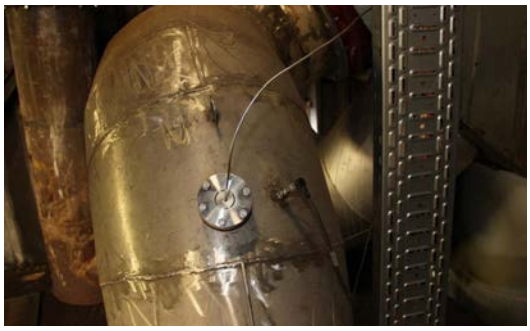
The pressure sensor features a measuring range from -1 to +10 bar. The analog output signal of the device is used to regulate the speed of the fan as well as the flap positions in the piping system.

ipf electronic_Bandstahl-Schulte_05:

The YT036020 PT100 probes are suitable for use in a temperature range from -30°C to maximum +350°C and, in the application at Bandstahl Schulte, are coupled to the temperature indicators (maximum ambient temperature +80°C) via a sensor-actuator cable .

ipf electronic_Bandstahl-Schulte_06:

Installed directly next to the isolating diaphragm is a YT036020 PT100 probe for monitoring the upper temperature limit.



ipf electronic_Bandstahl-Schulte_07:

The four YT353120 temperature indicators were mounted at a central location so that all values of the system can be clearly ascertained and monitored.

ipf electronic_Bandstahl-Schulte_08:

Initial findings show that the exhaust gases of the hydrogen bell-type annealing furnace can recover a great deal of heat using just a small amount of energy.