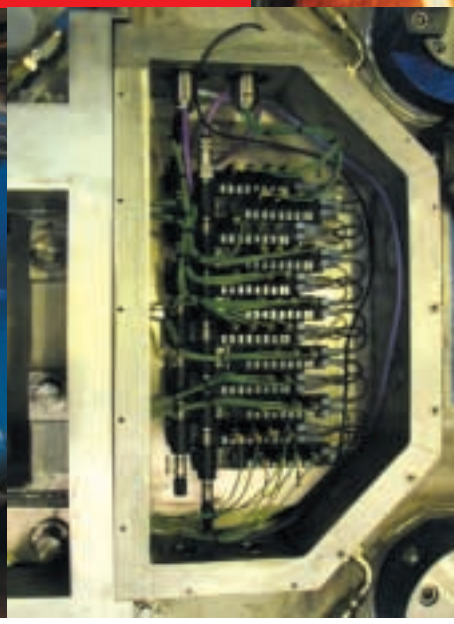
Fieldbus Box modules in action in a
continuous casting plant at SMS Demag AG

Data acquisition for breakout prediction systems

SMS Demag sets standards in the introduction of innovative technologies for breakout prediction systems in continuous casting applications. Temperature measurement via thermocouples has proven to be the most suitable and reliable technique. The Fieldbus Box modules in protection class IP 67 offer the basis for safe local signal acquisition.



In the continuous casting plants from SMS Demag, up to 100 thermocouple sensors are connected to the Fieldbus Box modules.

SMS Demag AG, headquarted in Germany, is an internationally leading manufacturer of metallurgical plant and rolling mill equipment. The company has been active for nearly 200 years and develops, constructs and builds machines and plants for the steel, aluminum and copper industries around the world. The range includes both system and automation solutions for the complete process chain, from iron making via steel plant, continuous casting, rolling mill and pipe technology to finishing lines for hot and cold rolled strip.

The continuous casting plants are used for the production of steel slabs that can be further processed into flat steel bars, so-called coils or wires, for example in rolling mills. The steel is liquefied in a blast furnace and vertically poured into a mold. The mold is the first part of a continuous casting plant and is decisive for the shape and first solidification of the subsequent product. The profile is almost rectangular; the length in the direction of production is approximately 1 m. On the inside, the mold is clad with copper plates that are equipped with thermocouple sensors for measuring the temperature.

During the start of casting, the mold is closed at the lower end with a dummy bar head, so that a stable skin can form in front of the plug and at the sides. Once this has solidified, the plug is removed and the slab is turned horizontal via appropriate rollers. It is then cut and further processed or transported to a warehouse.

During the production, a quantity of steel that matches the quantity removed is continuously poured into the mold. The flow rate must be adjusted in such a way that the bar can form a firm skin in the mold. Notwithstanding the addition of casting flux as a lubricant and the vertical oscillation of the mold there is a risk of the skin sticking to the copper plates and tearing.

Approximately 80 % of all breakouts are caused in this way. In order to prevent this, as many temperatures as possible are recorded and evaluated via gradient analysis. If irregularities are detected early, i. e. whilst the affected part of the slab is still in the mold, they can be healed, e. g. by reducing the flow rate.

Data acquisition – yesterday and today

The basis for successful early breakout detection (BPS, Breakout Prediction System) is reliable logging of the up to 100 thermocouple sensors that are located in several rows on the copper plates of the mold. Up to now, the usual method of recording the thermocouple signals was via multi-function couplers. A single coupler was used to record approximately 25 thermocouples, i. e. four such couplers were used in a mold. The sensors were connected with the

System topology and key data of breakout prediction systems

Fieldbus technology:

- Profibus Fieldbus Box modules with IP-Link extension modules (extremely EMC-safe through fibre optic connection of the extension modules)
- Protection class IP 67
- Extremely compact design
- Wiring of the sensors via pre-assembled cable sets
- Robust special plug connectors for Profibus hybrid line (fieldbus + supply voltage)

Real-time computer as data concentrator and evaluation system

- Industrial PC Pentium III, 850 MHz, 256 MB RAM, Profibus interface
- Real-time extension for Windows NT/2000/XP, 1 ms tic time, jitter ± 15 µs
- Programming in IEC 61131-3
- Real-time router with ADS system interface
- Standard ActiveX interface for visualization, diagnostics and database connection, techniques for accessing process and diagnostic data
- TCP/IP interface for remote access (network, remote service)
- Online visualization, online diagnostics
- Offline diagnostics for thermocouples and fieldbus modules (workshop system)
- Real-time database for trend analysis and process modeling

multi-function coupler via temperature-resistant master cables. This solution had the following disadvantages:

- High capital costs for the multi-function coupler
- High additional expenditure for installation and maintenance
- Limited diagnostic options

New solution – fieldbus technology directly at the mold

For these reasons, SMS Demag has developed a new data acquisition system, consisting of:

- Fieldbus Box modules in protection class IP 67 for acquisition and digitizing of the temperature signals
- Signal transfer via a Profibus network
- Industrial PC with TwinCAT automation software as a data concentrator

The temperature signals are recorded directly on the mold and transferred via Profibus to the PC control, which is equipped with the TwinCAT software PLC. The signals are recorded and pre-processed in real-time with a cycle time of approximately 250 ms, depending on the configuration of the bus system. The same PC also contains a real-time database that reads the data, detects impending breakouts via appropriate trend monitoring and evaluation algorithms, and initiates countermeasures.

However, in steel production applications, this data transfer system, which has already been the standard in general mechanical engineering applications, is subject to particularly extreme boundary conditions:

- Ambient temperatures up to 100° C
- Humidity up to 99 %
- Aggressive environment through the formation of hydrofluoric acid

All this calls for appropriate installation and protective measures, which have been developed along with the system and checked in test runs over several months. These measures are now successfully used in practice.

The first attempts

The history of the development provides insight into the obstacles that had to be overcome. The first approach to a solution, which mainly focused on monitoring the environmental conditions, consisted of a terminal box with integrated

SMS Demag AG –
High-tech for maximum cost effectiveness

The SMS Demag AG was formed in 1999 through the merger of SMS Schloemann-Siemag Aktiengesellschaft and the metallurgy arm of Mannesmann Demag AG. This merger combines two strong partners, whose ranges complement and strengthen each other optimally. SMS Demag AG is a company within SMS AG, the holding company of a group of international systems and mechanical engineering companies that process steel, non-ferrous metals and plastics. The group is subdivided into the sections of metallurgical and rolling mill technology, pressing and forging technology, and plastics technology. In 2001, around 9,700 employees worldwide generated sales of approximately 2.25 billion euros.

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Picture bottom left: The compact IP 67 modules are integrated into the water-cooled protective housing and thus protected from hydrofluoric acid at the same time.
Picture bottom right: A hybrid cable for bus and power supply replaces the multi-core master cables used in the previous solution.

Beckhoff Bus Terminals in protection class IP 20 for recording the temperature and the humidity. No further protective measures, e.g. cooling, were implemented. This exercise revealed temperatures of up to 85° C and humidity values of up to 99 % directly adjacent to the mold. A further difficulty was that extremely high moisture levels and, correspondingly, large quantities of condensation water were generated within the terminal box. This was due to the extreme temperature fluctuations within a very short space of time (e.g. directly prior to the end of the pouring process, the water cooling for the bar is switched off, which leads to a short-term temperature peak, followed by the plant cooling down to room temperature).

It therefore was apparent that the next attempt would require measures to ensure ambient temperatures in which the fieldbus technology could survive. The next terminal box was equipped with a sophisticated water cooling system that reliably limited the temperatures to a maximum of 40° C; however, the problem of the condensation water was still unresolved.

Practical, cost-effective and flexible solution

These considerations led to the use of the Fieldbus Box modules, designed in protection class IP 67. With the fully sealed, waterproof modules the formation of condensation water does not affect the safe operation of the data acquisition system. At the same time, SMS Demag implemented a special protective housing directly at the mold, which is surrounded by water for cooling and protects the Fieldbus Box modules from the aggressive hydrofluoric acid.

This system has been used since early 2001 in practice and has so far been installed at Aceria Compacta de Bizkaia S.A. (ACB) in Spain, ThyssenKrupp Nirosta in Germany and ThyssenKrupp Acciai Speciali Terni S.p.A. in Italy. The multi-core master cables have been replaced with a hybrid cable for bus and power supply. Two special plug connectors that were specially developed for the harsh ambient conditions supersede the fault-prone and expensive multi-function coupler.

Comprehensive diagnostics

The Fieldbus Box modules for recording the thermocouple signals each provide connection options for up to four sensors. Each channel can be monitored individually for measuring range violations (broken wire or short-circuit). These diagnostic functions can be used both during production and offline in the workshop.

SMS Demag developed a suitable diagnostics interface that accesses the variables from the TwinCAT PLC via the standard ActiveX Control interfaces and – after appropriate processing – displays them as process data (temperature) or diagnostic information (Profibus diagnostics, sensor diagnostics).

For the offline test, a system was developed as standard workshop equipment, which also consists of a TwinCAT computer with fieldbus interface and appropriate diagnostic software. It can be used to check all sensors of the dismantled mold. In the event of a thermocouple being faulty, the sensor plug simply has to be disconnected, and the thermocouple removed and replaced with a new one. The same applies for a faulty fieldbus module.