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Corrosion – don't get rusty

Cost reduction in power plants due to online corrosion monitoring

CorrTran™ MV from Pepperl+Fuchs is the very 2 wires, 4...20 mA transmitter with integrated HART protocol and built-in functionality to detect general and localized corrosion. It replaces conventional lab-based analysis and allows real-time corrosion monitoring as part of everyday process control. The industry-standard casing contains a range of innovative technologies which put plant operators into the position to react to corrosion before it can lead to far-reaching consequences. It represents an effective means for cost reductions for example in power plants or closed-circuit cooling systems.

What corrosion is all about

The term corrosion describes what everyone knows when his car shows rust or electric contacts do not function anymore, because they are corroded. Objects made of steel often remain fully intact, while the body of an old car will eventually collapse completely, because the metal under the paint has turned into a brown, powdery material. According to the German Industry Standard DIN 50900 part I, corrosion describes the reaction of metal to its environment, resulting in measurable changes in the material, which may change the characteristics of a metallic object or the complete system it is part of, thereby degrading its function. In most cases it is an electrochemical reaction that leads to corrosion, but it might also be the result of a chemical or metal physical reaction. This definition already indicates that corrosion means far more than simply rust.

In some industrial processes, such as in power plants, damages caused by corrosion represent a tremendous cost factor. For example, steam generators are used in virtually any industry. Just about any manufacturing plant at least operates one generator of this type. Yet, all steam generators are subject to the damaging and thereby costly effects of corrosion. It is estimated, that corrosion causes annual costs of more than 210 Billion Euro. This

includes areas, such as public utility companies (36.5 Billion Euros), as well as the paper and cellulose industry (4.6 Billion Euros).

Steam made from pure water

Industrial plants generate electricity for their own use. Public power plants produce electricity for public use. Both use power generators of differing dimensions. However, all of them need the same type of pure water which is made from raw water that is passed through a number of filter and demineralization stages.

This continuous flow of purified water is fed into the steam generator which produces the steam that drives the turbine used to generate electricity. Part of the steam is used to preheat the pure water before it enters the steam generator. After passing through the generator, the steam turns into condensate, which is then collected and fed back into the cycle together with newly purified water. The overall construction of such a power plant depends on the thermodynamic characteristics typical of the respective plant. Energy generation requires high investments into technology. This means, maintenance of the system is of vital importance in order to keep profitability, safety and life cycle at a high level.

Pure water has corrosive effects when it gets in contact with the steam generator and the condensing system. In addition, leaks may result in chemicals entering the system, thereby increasing the corrosive effect. For example, a leaking condenser might lead to untreated cooling water mixing with the purified water. Leaking seals at the turbines and pumps might allow oxygen to enter into the feeding water and increase its aggressive potential. In order to prevent such risks, special corrosion inhibitors are usually added to the feeding water.

In order to protect the capital investment of the power plant, effective chemical-physical treatment of the feeding water is absolutely necessary, especially during maintenance work at the boiler and condensing systems.

Poor quality of the water fed into the boiler may lead to severe problems, such as tinding, pitting or corrosion of the components inside the boiler and condensing systems. The danger of corrosion can be limited by means of adding special chemical additives to the purified feeding water. Most plant operators measure the water quality by means of conductivity sensors and/or pH probes. However, while such measurements are suitable to sufficiently analyse the water quality, they provide no information as to the condition of the piping of the condensing systems.

Practical solution

Using the 4...20 mA real-time signal of the CorrTran™ MV transmitter, plant operators are able to compare historical corrosion data with up-to-date measurements. In this way, they can determine instantly whether the water quality has changed, whether there are changes in the chemical setup of the water or whether the corrosion inhibitors perform correctly. All these conditions have an effect on the corrosion of the piping and can be detected and monitored efficiently with help of CorrTran™ MV. Following the principles of proactive maintenance, the plant operator is able to prepare and schedule the exchange of components affected by corrosion before the effect of corrosion leads to costly damage. The unique performance of CorrTran™ MV assists the operator in monitoring both general and local corrosion. Especially local corrosion can lead to severe damage if it is not detected at an early stage. This type of corrosion is able to actually puncture a pipe within a short time. Yet, it can be counteracted effectively if corrective measures are taken before it is too late. In other words: CorrTran™ MV makes it possible to monitor and control corrosion just like any other process parameter.

Real-time monitoring of the corrosion rate

At the core of CorrTran™ MV are modern and patented algorithms and data analysis techniques to provide exact measurement of corrosion rate and local corrosion (pitting). To measure the general corrosion rate, the system determines the linear polarization resistance (LPR), thereby using a generally accepted industry standard. This method is further optimized by an additional harmonic distortion analysis (HAD). During the measuring cycle, the corrosion sensor also performs an electrochemical noise (ECN) measurement which allows a dependable determination of pitting. At the end of each measuring cycle, the respective corrosion rate and the pitting value are calculated and provided via HART and/or as a 4...20 mA signal.

The LPR method is the generally accepted industry standard used for general corrosion monitoring. It is based upon the Stern-Geary relationship, which describes the general relationship between the polarization resistance and the corrosion current. Provided the corrosion current is known, calculation of the corrosion rate is a simple process. The polarization resistance again can be determined on the basis of the measured current and the stimulation potential of the measuring electrodes (provided their potential is sufficiently low). HDA analysis allows calculation of the general corrosion rate without the need to know the board constants (B value), which are an elementary part of the Stearn-Geary relationship. In this way, feeding a low-frequency sinus-wave voltage to the measuring electrodes and analyzing the distortions is sufficient to determine the general corrosion rate.

CorrTran™ MV combines both procedures in an ideal way in order to gain dependable and fast measuring results. This includes determination of the B value. In order to further increase precision, conductivity measurements are also included into the calculation. The resulting value provides additional valuable information concerning the state of the electrodes. Additionally, the ECN method is used to measure the intensity of local corrosion. ECN describes the measurement of spontaneous potential fluctuations which are generated randomly at the corroding interface between metal and solution. Statistic analysis of the measured current allows the determination of a pitting factor which is an indicator of the speed and intensity of local corrosion.

Specifications

The standard probes used by CorrTran™ MV for corrosion detection, consist of three electrodes. One of them induces a low-power signal, while the others measure the resulting potential and current. In order to gain precise measuring results, these electrodes need to be made of the same material as the piping or container to be monitored. The electrodes are placed immediately within the flow of the corrosive media and are induced with a weak signal. Within only a few minutes, this signal is monitored and analyzed by the transmitter in order to gain an exact impression of the rate of corrosion. As a result, service technicians are required with the needed information to schedule repair and service work according to the actual need, putting them into a position to react before corrosion has gone too far and degrades the ongoing process. In this way, CorrTran™ MV not only contributes to saving time and costs. It also is the basis for proactive maintenance and makes corrosion monitoring part of the daily routine.

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Main visualization



Fig. 1: CorrTran™ MV compact version



Fig 2: Corr Tran™ MV electronics unit