Typical Problems in Industrial pH Measurement & Control - Part I

Monitoring the quality of water is one of many important aspects in environmental control. With the increasing growth in human population, water for human consumption has become scarce and increasingly polluted. There are many parameters that define the quality of water but the most important of these is probably pH.

The common problems faced by industry in the measurement of pH and to discuss how these problems may be overcome by Eutech's alpha-pH1000 controller are highlighted as follows:

Electrical Interference

pH is a deceptively simple measurement. However, there are many factors that need to be taken into account for a reliable reading. The most important characteristic of pH electrodes is it's very high impedance, of the order of 10^9 ohms. This is compounded by noisy factory environments and by long distances between the electrode and the controller.

A typical pH measuring device would be normally configured to operate in the single ended mode, also known as the asymmetrical mode. This means that the reference electrode would be connected to the ground potential of the amplifier. This configuration works very well as long as the environment is electronically noise-free. This is not the situation in an industrial environment. It is very commonly seen that the readings on a pH controller suddenly fluctuates, even to over-range or under-range condition. This situation arises, when for example, the mixing motor is switched on. An old leaky motor might inject some electrical interference of 1 to 2 volts into the liquid whose pH is monitored. This noise being a common signal, is picked up by both the pH and the reference electrodes. Since in the asymmetrical mode, the reference electrode is grounded, the electrical noise is present only on the pH electrode. This noise would be amplified along with the pH signal and thus the fluctuating readings. If the electrical noise was from a DC source, typically like those in an electroplating tank, the problem would not be fluctuating readings mostly stable but incorrect values.

A simple way to solve this problem would be to reconfigure the input to floating differential mode. In other words, not to ground the reference electrode. Therefore, the electrical disturbance will be present equally on both the pH and reference electrodes. It therefore becomes a common mode signal and hence can be rejected very easily by the operational amplifier. However, this brings in the necessity to use an additional grounding electrode commonly referred to as potential matching pin.

Relay Hunting

Hunting of the relays around the set point is a very common problem faced in the industry. This may even lead to the breakdown of expensive dosing pumps and solenoids at times. Let us look at what causes this problem. Let us assume that in a typical case, a low set point of 6 pH has been set. It would mean that when the pH drops to a value below 6, the caustic dosing pump starts. The addition of caustic solution would start to increase the pH. When the pH reaches 6, the pump would stop. The mixing pump would still continue operating and hence the pH would drop back below 6. This would start the cycle all over again and so on. This results in the hunting of the relay around the set point.

A simple way to overcome this problem would be allowing the pump to continue to dose even beyond the set point, say until 6.5 pH in the above example. In such a situation, when dosing pump stops, the pH might drop to probably 6.2 pH which is still above the set point and hence hunting is prevented. This extra band that has been introduced is known as the hysteresis band. In modern day controllers, independent and adjustable hysteresis bands are available for the high and low set points.

Limit and Proportional Control

The function of a pH controller would be mainly to monitor the pH and activate the pumps if the pH value goes out of the set points, and dose the respective chemicals which would bring the pH back within limits. The manner in which this corrective action takes can be in two ways, namely limit control and proportional control.

Limit control is a coarse method since it keeps the relays on permanently if the pH is out of limits. The dosing of the chemical would not be regulated based on the deviation of the pH from the set point but at a steady and fixed rate. This would cause overshoot and undershoot of the process and hence the control will not be smooth.

In applications where fine control is required like those in food or pharmaceutical applications which usually operate within a narrow band, a limit control would not be acceptable. The best option would be to switch to 'Proportional Control'. This, as the name suggests, would offer a control action which is proportional to the deviation of the pH value from the set point. In other words, the further the pH value from the set point, the longer the dosing. As the pH approaches the set point, the dosing reduces and finally stops when the pH reaches the set point.

There are two methods of applying 'proportional control', Pulse Length and Pulse Frequency. In the pulse length mode of operation, the total time of the pulse can be fixed by the user typically anywhere between point 0.5 and 20 seconds. The 'ON' time of the pulse would vary depending on the deviation of the pH from the set point. The further away the pH, the longer the 'ON' time and hence, the higher the dosing. As the pH approaches the set point, the 'ON' time and hence dosing keep reducing.

In the Pulse Frequency mode of operation, the frequency can be set by the user typically anywhere between 60 and 120 pulses per minute. The frequency of the pulse would vary depending on the deviation of the pH from the set point. The further away from the pH from the set point, higher the frequency, hence higher dosing. As the pH approaches the set point, the frequency and the dosing reduces.

In-Line Calibration

In most of the industrial applications, the pH controller would be calibrated at the beginning of the process. As the process progresses, bleed samples would be taken and analyzed separately in the laboratory. At times, it is noticed that there is a mismatch between lab results and the readings on the controller. This might have come about due to the soiling of pH electrode being used in an aggressive environment which might also be a long process running a few days in some cases. In order to correct this problem, the electrode may have to be taken out of the process tank which means halting the process. This may not be acceptable in most cases. A simple way to overcome this problem would be to provide a facility of a one-point calibration which can be done on-line. This does not affect the original slope of the calibration but offsets the line. alpha-pH1000 controller allows one-point on-line calibration to be done without having to disassemble the electrode housing.

Current Transmission - 4/20 mA

In most industries these days, it is essential to have a hard copy of the parameter that is monitored over the entire time frame of the process. The easiest and most economical way of achieving this would be to connect up the controller to a chart recorder. It is therefore necessary for the controller to have a 4/20 mA transmission capability. Most present day controllers come with this facility built in. However, there are only a few which offer many features in this mode.

Conventionally, in the controllers, 4 mA would correspond to 0 pH and 20 mA to 14 pH. When such a device is connected to a 1/4 DIN panel mounted chart recorder, the pH value can be constantly monitored. If the process requires a stringent control and is also operating within a narrow band of set points, say 1 pH; the recording on the chart paper will not be well resolved. This is due to the fact that in the conventional controller the range of 14 pH is distributed over 16 mA. It can therefore be seen for a 1 pH variation, the current varies only by 1.15 mA approximately. This on the chart paper would be a movement across a width of less than 1/2 cm for the recorder mentioned above It is clear from this example that recording would not be well resolved and hence would not be of much use.

An easy and economical solution to the problem would be to have a controller with 'zoom' facility for the current output. This in simple terms would mean that the user should have the facility to fix the pH values he wants to the 4 and 20 mA output. Let us consider a process operating within 1 pH band say 6 and 7 pH. If it was possible to se the controller to deliver 4 mA at 6 pH and 20 mA at 7 pH, it can be seen that we now have the entire 16 mA over just 1 pH band. This has now given us a 'zoom' of almost 14 times. It would be an added advantage if this 'zoom' band could be set anywhere on the entire pH scale.

Please refer to Part II of Typical Problems in Industrial pH Measurement and Control for more details.

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